Office of the Commissioner for Aquaculture Development

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Study No. 7

The International Context for Aquaculture Development:

Growth in Production and Demand, Case Studies and Long-Term Outlook

by
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FOREWORD

In order to provide a report on the federal government role in aquaculture for the Minister of Fisheries and Oceans, the Office of the Commissioner for Aquaculture Development has undertaken a series of background studies pertaining to aquaculture. The studies are:

Study 1 : Current Status and Potential of the Canadian Aquaculture Industry: a review of the context in which the Canadian aquaculture industry is evolving today, and an assessment of its potential for future growth;

Study 2 : International Fish and Seafood Markets: a Canadian perspective: a review of general trends in international fisheries products markets (commercial fisheries and aquaculture) in light of major markets targeted by Canadian aquaculture products;

Study 3 : Market Outlook in the International Fish and Seafood Sector: Alternative Products/Uses and Food Safety Issues: a review of general trends affecting the value-added of fisheries products, new uses for products derived from aquaculture and commercial fisheries (pharmaceutical products, nutraceuticals, etc.), and issues affecting food safety, especially in terms of consumer behaviour and regulatory changes affecting international trade;

Study 4 : Review of Provincial and Territorial Programs and Services in the Aquaculture Sector: a review and analysis of all programs and services provided to the Canadian aquaculture sector by provincial government ministries/departments and agencies;

Study 5 : Review of Federal Programs/Initiatives in Support of Aquaculture: a review and analysis of all programs and services provided to the Canadian aquaculture sector by various federal government departments and agencies;

Study 6 : Federal Programs and Services for Five Resource-Based Industries: a comparative analysis of how the aquaculture sector is treated by the Canadian government, in comparison with four other primary sectors : agriculture, forestry, commercial fisheries and biotechnology;

Study 7 : The International Context for Aquaculture Development: Growth in Production and Demand, Case Studies and Long-Term Outlook: a review and comparative analysis of the international context and resulting major trends that will affect the development of aquaculture at the global, national and regional levels; includes an overview of policies, governance structures, programs and services in place in various countries to provide a framework and support for industry, and to foster smooth development of aquaculture; and, the lessons for Canada.

EXECUTIVE SUMMARY

Purpose of the study

The Government of Canada is reassessing its support role for development of the country's aquaculture sector, to help it more effectively in capitalizing on opportunities for growth. The central purpose of this study is to profile the growth of global production and demand for aquaculture products, and identify the factors that will determine aquaculture performance in the coming years, specifically including government intervention elsewhere in the world. The ultimate goal is to assess more effectively the future context in which Canadian aquaculture will operate, to the best of our knowledge and based on data currently available, and to adapt Canadian government activities accordingly.

Global trends

Over the past 30 years, global aquaculture production has grown from 3.5 million tonnes in 1970 to more than 45 million tonnes in 2000, an average annual growth rate of about 8.9%. From 1995 to 2000 alone, including production of aquatic plants, aquaculture production volume has risen from more than 31 million tonnes to more than 45 million tonnes, an increase of 14.5 million tonnes and an average annual growth rate of 7.9%. If production of aquatic plants is excluded, this rate climbs to 8.5%.

Based on FAO forecasts and our assumptions, it appears that global aquaculture production could reach some 118 million tonnes in 2030 to meet demand, a level three times the output for 2000, or an average annual growth rate of about 4%.

In 2030, aquaculture will be the main source of supply of fish, as less than half of seafood consumed will come from fishing catches. However, production-related constraints could cut into market supply.

Main findings of the case studies

The status of the aquaculture sector in eight countries was analysed in terms of production trends, industry organization, governance structures, recent developments and current issues. Moreover, a description of the main programs and services provided by the national government is provided. These countries were selected based on similarities between their aquaculture sectors, target markets or government structure and the Canadian situation. This list includes Australia, Chile, Spain, the United States, France, Norway, New Zealand and the United Kingdom. Based on the growing level of economic, social and political integration among member countries of the European Union and direct EU involvement in aquaculture, the author thought that it would be useful to conclude this section with an analysis of this political organization's involvement in aquaculture.

Of all the countries studied, Chile posted the strongest average annual growth between 1995 and 2000, at 15.6 %, a virtual doubling of production in six years. France posted the worst performance with an average decline in production of 1% a year. Australia, Norway and the United Kingdom achieved annual growth of 12.3%, 11.9% and 10.2% respectively. In every case, this resulted in a sizeable increase in production, by a factor of 1.8 in Australia and Norway, and 1.6 in the United Kingdom. Spain posted a rate of 6.9%. Aquaculture production in the European Union rose from 1 to 1.3 million tonnes, with average annual growth of 3.5 %. The United States achieved modest annual growth of 0.7%.

The main findings of the case studies are summarized below.

- All countries studied support sustainable development of aquaculture. This support varies from country to country, however, and is justified in the opinion of national governments by a combination of advantages and benefits that also vary from one country to another. The list of socio-economic benefits includes that fact that aquaculture is a reliable source of quality foodstuffs, that this sector creates jobs and wealth, is a source of foreign exchange, makes a major contribution to regional development, involves use of land, etc.

- The obstacles to aquaculture development fall under two major constraints: the environmental impact of farming in a receptive natural environment (impact that is real or incorrectly attributed); and current policies and a legal and regulatory framework unsuited to the sector's needs. Major progress has been achieved in the environmental performance of aquaculture businesses and in terms of national public opinion regarding the sector's image. In fact, a country such as Norway believes that all environmental issues have been addressed and effluents of nutrients from industry are no longer considered an environmental problem. Current issues in Norway now centre more on health of farmed animals and controlling escapes of fish.

- In most of the countries studied, the national government, in conjunction with the industry, has established or is about to introduce a clear policy to promote sustainable development of aquaculture. This policy is often accompanied by production targets for the medium and long term. In these countries, production value is expected to increase by a factor ranging from 1.4 over the next five years, to 8.4 over the next 20 years. Moreover, most countries have developed or are completing action plans with specific methods to implement this policy and achieve the targets set.

- In most cases, national production is not very diversified. The list of species produced in significant volumes is quite short. This is even more striking in terms of tonnage: the vast majority of national production often consists of just one or two species.

- Countries that have posted strong growth in production, such as Chile, Norway and Spain, have legislation specific to aquaculture. New Zealand will pass such legislation in 2003. Others such as Australia and Scotland are planning to implement legislation over the short term. One objective of such legislation is legal recognition of this new major economic sector and thus, clarification of current issues such as ownership of farmed animals and exclusive access to and use of a public resource.

- All countries still have room for expansion in the operation of existing sites. In some cases, new sites are readily available near the coast. Finally, several countries are considering the development of technology for culture offshore. Sea ranching is also seen as an activity with good growth potential and an excellent way to promote involvement by the fisheries sector in aquaculture.

- All national governments are now modernizing their capabilites to act fairly quickly, but the level of advancement varies between countries. Australia, Chile, Spain, France, Norway, New Zealand and Scotland will have a new aquaculture policy in effect in 2003 and/or new legislation specific to this sector.

- By transferring more decision-making power to local authorities in order to solve the problem of conflicts between users of the aquatic environment, three countries apply integrated resource management concepts (Australia, Chile and Norway) and two others plan to start using these concepts in 2003 (New Zealand and Scotland). For its part, the European Union has issued a new directive to this effect in 2002, urging member countries to introduce such practices.

- Integration of aquaculture activities into those of related sectors such as agriculture and fisheries is seen by several countries as a tool to foster development and a way to create synergy for optimizing benefits for the producer and the national economy. Australia favours integration of freshwater aquaculture (land-based) into agricultural activities. Chile has adopted new regulations favouring the granting of marine concessions to communities of fishers for development of sea ranching activities. Norway increasingly refers to a halieutic sector encompassing traditional fisheries activities as well as aquaculture. In its new aquaculture development strategy, the European Union openly advocates shifting the fisheries workforce to aquaculture in areas affected by a sharply declining catches.

- In most countries, national industry organizations have adopted a code of good conduct or codes of good practice.

- Most countries provide direct financial support for business development, to expand production capacity and/or enhance the competitiveness of existing production units. Chile, the United States and New Zealand are the only exceptions. The European Union, with its *Fisheries Guidance Financial Instrument*, is showing strong leadership for member countries and its joint intervention with these countries covers all segments of the industry, from production to organization of marketing, as well as processing and improvement on quality product.

- Only the United States and Spain currently have harvest insurance programs established specifically for aquaculture, covering respectively the farming of quahogs in USA and gillthead bream, sea bass, turbot, mussel and trout farms in Spain. In USA, the quahog program is a pilot project that will be subject to a full review in 2004. Other American products, such as Atlantic salmon, may be covered by such programs in the foreseeable future. In Spain, the programs are also at the experimental stage.

- All governments of the countries studied, without exception, allocate significant resources to research and development. All of these countries possess what may be called a national R&D institute for aquaculture (often in conjunction with the fisheries sector) that supports intramural and/or extramural programs of research. Several provide funding for research in other public or private institutions, and directly to businesses conducting R&D projects.

- Norway is the only country that has established a fisheries and aquaculture research fund under the responsibility of the Ministry of Fisheries, with 100% of funding being provided by fisheries and aquaculture businesses through mandatory deductions from their export income. The industry plays a decisive role in grants from this fund to R&D projects. Since this fund is barely a year old, it is still too early to assess its performance.

- All governments also allocate resources to technology transfer activities in cases where these are a key component of the innovation process, fostering adaptation and use by the industry of new technology and other results from R&D.

- It should be noted that a few countries, such as Australia, the United States and France, are actively promoting the development of offshore farming technology. These government initiatives are justified for various reasons, ranging from a lack of adequate inshore sites for desired expansion of the sector, to resolution of conflicts between users of the aquatic environment through moving aquaculture installations away from the coast.

- Most countries have introduced a national aquatic animal health program that takes an integrated approach to this important aspect of aquaculture and delivers traditional services to the industry for health monitoring, as well as monitoring and rapid response measures for any emergency resulting from an epidemic. These programs receive significant financial support from the central government, although it continues to be deemed inadequate.

- The wholesomeness and safety of aquaculture products are considered to be major and vital components of government intervention in all the countries studied.

- A strengthening of standards may currently be observed in most countries, which provides one more argument in support of export sales from a given country but an additional barrier to seafood imports into the same country.

- All national governments directly support development of foreign markets and exports of aquaculture products. This is done through programs introduced specifically for aquaculture (Australia, European Union member countries) or through more generic programs (Norway).

- Two countries have national organizations dedicated to promoting exports of their aquaculture products: Norway and Scotland. Norway's council for the export of marine products was created through legislation and is funded through mandatory deductions on all products exported from Norway. Scottish Quality Salmon (SQS) is a completely private corporation, also funded through deductions from exports of Scottish products, but these are voluntary as they apply solely to exports by businesses that have decided to become members and thus take advantage of the services provided by SQS.

Conditions that promote success

At both the international and regional levels, in order for aquaculture to contribute fully to the supply of fisheries products needed for food security in the future, it must rise to the many challenges it now faces.

The factors that will determine the ability of aquaculture to capitalize on available opportunities for growth are:

- compliance with principles of sustainable development;
- inclusion of aquaculture in the local and national social fabric;
- maintenance of industry competitiveness;
- irreproachable safety of aquaculture products;
- a good image of the sector and its products in the eyes of consumers and in the opinion of the public generally; and
- government action to promote growth of this new sector.

Analysis of supply and demand for fisheries products reveals solid potential for growth of aquaculture in the coming years. However, a comprehensive strategy for achieving this potential must include two components: 1. a significant increase in production to ensure that there continues to be an increasing effect on global food securit, the creation of economic benefits, rising household wealth and, thus, enhanced social equity; 2. development that reflects the environment's capacity to support operations based on the dictates of sustainable development.

Several national governments have strived to provide a more effective framework to develop this sector. This is not driven by a desire to restrict or control expansion of an industry that has at times performed poorly in environmental or social terms, but rather by the enormous potential of aquaculture and the need to modernize the legal and regulatory structure to support sustainable development of the sector.

Every industrial activity has an impact on the environment. Ultimately, a society must choose the type of food production that provides the best return on the private or public resources used, produces foods and others products that best meet current and future consumer needs, generates the best economic and social benefits, and has the least impact on the environment, with such effects being reversible. Many governments around the world have specifically declared, or are preparing to state officially that this type of production includes aquaculture.

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INTRODUCTION

Canada's aquaculture industry operates in an international context that has a decisive impact on its future. Canadian aquaculture products are destined primarily for export markets and it is quite likely that this dependency on foreign markets will continue to exist, if not grow.

Given that the Government of Canada is reassessing its role of supporting development of Canada's aquaculture sector to help that sector more effectively to capitalize on opportunities for growth that arise, the main purpose of this study is to develop a profile of the growth in global production and demand for aquaculture products and identify the factors that will determine aquaculture performance in the coming years, specifically including government interventions in other countries. The ultimate goal is better assessment of the context in which Canada's aquaculture industry must operate in future, based on the best knowledge and data currently available, and to adapt Canadian government interventions accordingly.

To this end, **Section I** of this study discusses growth in global production in recent years, by volume and value, and also by farming environment, species and main producing countries. Very special attention is paid to world salmon production since this is Canada's main product. To develop a more comprehensive vision, this same section also details regional production trends in volume and major species produced for Asia, Europe, South America, North America, Africa and Oceania.

Section II presents nine case studies. The prevailing situation of aquaculture in eight countries is described in terms of production trends, industry organization, govenance structure, recent developments and current issues, as well as the major programs and services provided by the national government. These countries were selected for the similarities in their aquaculture sectors, target markets or governance structure to the situation in Canada. The eight countries are Australia, Chile, Spain, the United States, France, Norway, New Zealand and the United Kingdom. Given the growing economic, social and political integration of European Union member countries and direct EU involvement in aquaculture, we decided to conclude this section with an analysis of intervention in aquaculture by this political organization.

Finally, **Section III** presents the long-term global outlook for aquaculture, especially in supply and demand, as well as a summary of the case studies and a description of the main factors that will determine the aquaculture sector's ability to achieve its enormous growth potential over the next three decades.

It should be noted that markets and marketing trends, alternative products/uses and food safety issues are given only brief coverage in this study, since these issues are addressed in other studies published by the Office of the Commissioner for Aquaculture Development (Study 2 and Study 3).

Note: All dollar amounts are in Canadian dollars unless otherwise indicated in the text.

SECTION I

THE INTERNATIONAL CONTEXT FOR AQUACULTURE DEVELOPMENT

GROWTH IN WORLD AND REGIONAL PRODUCTION

1.1 GROWTH IN WORLD PRODUCTION

1.1.1 General overview (production)

The availability of fisheries products from commercial fisheries and aquaculture rose from 124 to almost 142 million tonnes between 1995 and 2000 (Table 1.1). This 18-million-tonne increase in production is essentially attributable to aquaculture, since fisheries landings have remained fairly stable.

Over the past 30 years, world aquaculture production has risen from 3.5 million tonnes in 1970 to more than 45 million tonnes in 2000, an average annual growth rate of about 8.9%. For 1995-2000 alone, including production of aquatic plants, aquaculture volume rose from more than 31 million tonnes to more than 45 million tonnes, an increase of 14.5 million tonnes and an average annual growth rate of 7.9% (Table 1.1). When production of aquatic plants is excluded, this rate rises to 8.5%.

Table 1.1 World fisheries production (commercial fisheries and aquaculture), 1995-2000

Types of products	World fisheries production (tonnes)					
	1995	1996	1997	1998	1999	2000
Aquaculture						
Freshwater or diadromous fish	14,447,908	16,432,511	18,056,986	19,081,542	20,764,082	22,058,310
Shellfish (excl. Cephalopods)	8,230,297	8,488,197	8,558,401	9,140,613	10,145,184	10,732,154
Aquatic plants	6,792,571	7,176,733	7,204,767	8,555,045	9,547,606	10,130,448
Crustaceans	1,130,379	1,159,240	1,246,119	1,390,181	1,543,317	1,647,720
Other saltwater fish	159,034	192,844	281,282	336,450	364,887	445,294
Demersal saltwater fish	198,718	225,502	260,082	285,292	337,793	405,888
Saltwater pelagic fish	180,522	154,733	147,343	162,778	158,444	158,481
Misc. aquatic animals	55,609	62,499	82,289	110,310	133,071	137,236
Cephalopods	<0.5	1	4	33	33	28
Total aquaculture	31,195,038	33,892,260	35,837,273	39,062,244	42,994,417	45,715,559
Total aquaculture (excl. aquatic plants)	24,402,467	26,715,527	28,632,506	30,507,199	33,446,811	35,585,111
Total commercial fisheries	93,245,456	94,665,787	95,140,816	88,405,278	94,474,953	96,083,219
Grand total	124,440,494	128,558,047	130,978,089	127,467,522	137,469,370	141,798,778
Grand total (excl. aquatic plants)	117,647,923	121,381,314	123,773,322	118,912,477	127,921,764	131,668,330
% Aquaculture	21%	22%	23%	26%	26%	27%

Source : FAO Fishstat Database Version 2.3. 2002.

Aquaculture represented about 27% of total fisheries production in 2000 compared with 21% just six years earlier (Table 1.1 and Figure 1.1). Aquaculture's relative share of total world fisheries production therefore has risen steadily in recent decades and it is a given that this trend will continue, as we will see later.

In 2000, world aquaculture production was largely dominated by freshwater or diadromous fish, which represented 48% of products. This was followed by shellfish at 23% and aquatic plants at 22% of production.

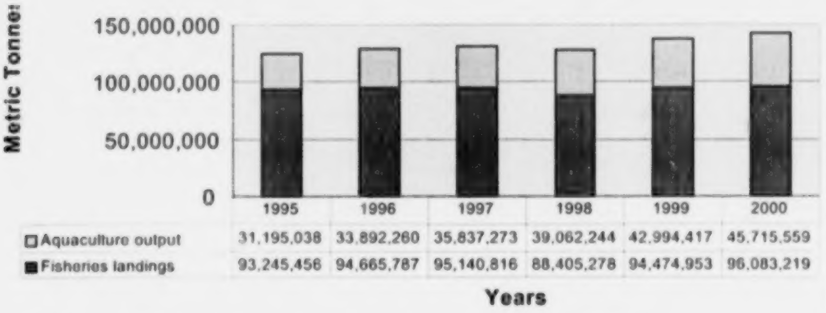


Figure 1.1 World production of fisheries products, 1995-2000

1.1.2 General overview (value)

In value terms, aquaculture posted equally impressive growth from 1995 to 2000, rising from more than US$44 billion to more than US$56 billion (Table 1.2).

Production of freshwater and diadromous fish in 2000 represented about 48.7% of the total value, with more than US$27 billion, while production of shellfish and crustaceans represented 16.8% and 16.6% respectively.

For the same period, the value of a tonne of products (all products combined) declined from US$1,428 to US$1,235, a drop of about 13.5% over six years. If aquatic plants, which have the lowest value per tonne, are excluded, unit value declines from US$1,622/tonne in 1995 to US$1,429/tonne in 2000, a drop of 12%. This downward trend in the value of a tonne of production is consistent with the traditional economic model that increased production promotes greater competition and thus declining production costs and market prices.

All major species groups in production posted a decline in unit value except saltwater pelagic fish, which actually rose substantially in value per tonne, from US$7,511/tonne to more than US$9,200/tonne.

In terms of unit value, saltwater pelagic fish hold a strong lead, followed by crustaceans and demersal saltwater fish. The groups with the lowest production levels and composed of several species with emerging production post the highest unit price. Well-established products that have achieved productivity gains have a lower unit value. This is true of many species of shellfish and freshwater or diadromous fish, such as salmonids. This greater productivity is often due to improved technical and biological performance, or to management practices.

Table 1.2 Value of world aquaculture production, 1995-2000

Types of products	Value (US$1,000)					
	1995	1996	1997	1998	1999	2000
Freshwater or diadromous fish	20,485,800	22,890,373	24,385,260	24,841,946	26,046,797	27,492,953
Shellfish (excl. Cephalopods)	8,335,028	8,587,081	8,696,713	8,467,405	9,027,211	9,496,503
Crustaceans	7,208,680	7,408,792	7,682,362	7,973,434	8,815,429	9,371,794
Aquatic plants	4,952,259	4,845,484	4,897,373	5,391,158	5,704,630	5,607,835
Demersal saltwater fish	1,835,359	1,883,241	2,078,695	1,895,618	2,044,808	2,264,939
Saltwater pelagic fish	1,355,821	1,320,947	1,259,943	1,204,852	1,480,932	1,462,856
Misc. aquatic animals	179,296	233,034	280,806	327,217	380,436	425,634
Other saltwater fish	190,679	182,328	290,017	322,890	371,118	344,357
Cephalopods	<0.5	4	16	132	132	112
Total	44,542,920	47,351,283	49,571,185	50,424,650	53,871,492	56,466,982
Total (excl. aquatic plants)	39,590,661	42,505,800	44,673,813	45,033,492	48,166,862	50,859,147
	Value US$/tonne					
Value (US$/tonne)	1,428	1,397	1,383	1,291	1,253	1,235
Value (US$/tonne) (excl. aquatic plants)	1,622	1,591	1,560	1,476	1,440	1,429
	Value US$/tonne for major species groups					
Saltwater pelagic fish	7,511	8,537	8,551	7,402	9,347	9,230
Crustaceans	6,377	6,391	6,165	5,736	5,712	5,688
Demersal saltwater fish	9,236	8,351	7,992	6,644	6,053	5,580
Cephalopods	NA	4,200	4,050	4,006	4,009	4,000
Misc. aquatic animals	3,224	3,729	3,412	2,966	2,859	3,101
Freshwater or diadromous fish	1,418	1,393	1,350	1,302	1,254	1,246
Shellfish (excl. Cephalopods)	1,013	1,012	1,016	926	890	885
Other saltwater fish	1,199	945	1,031	960	1,017	773
Aquatic plants	729	675	680	630	597	554

Source : FAO Fishstat Database Version 2.3. 2002.

1.1.3 Aquaculture environments

Figures 1.2 and 1.3 present the breakdown of world production in terms of the various aquaculture environments, salt water, fresh water or brackish water respectively, excluding and including aquatic plants.

If aquatic plants, the vast majority of which are produced in saltwater, are excluded, more than 58% of world aquaculture production occurs in fresh water, 36% in saltwater and 6% in brackish water (Figure 1.2).

If aquatic plants, which have posted strong growth between 1995 and 2000, are included, mariculture and freshwater production represent 50% and 45% respectively of world aquaculture, while brackish water generates about 5% of the total (Figure 1.3).

Over the period in question, these proportions have remained fairly stable. No trend has emerged favouring massive growth in production in a given environment. However, mariculture should experience significant growth, as we will see later.

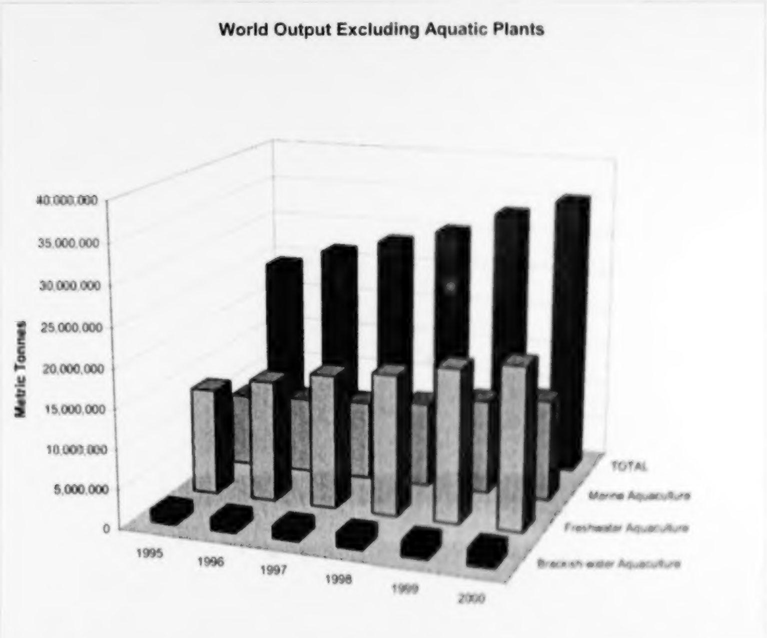


Figure 1.2 World production of fisheries products (excluding aquatic plants), 1995-2000 and by type of aquaculture environment

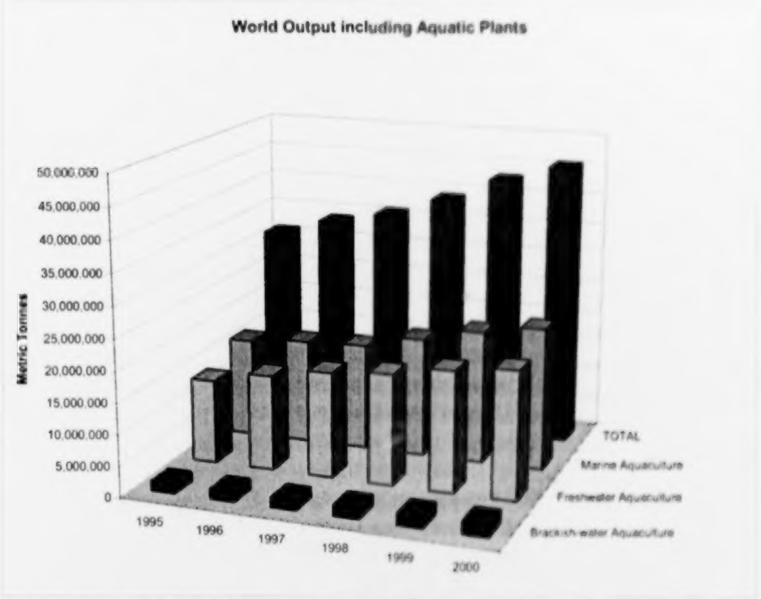


Figure 1.3 World production of fisheries products (including aquatic plants), 1995-2000 and by type of aquaculture environment

1.1.4 Main species produced

The FAO reports that some 380 species are produced in aquaculture around the world. Table 1.3 presents the list in declining order of production for the 25 most common aquaculture species in 1995 and 2000.

Table 1.3 *The 25 species with the largest world production in 1995 and 2000*

Production in 1995			Production in 2000		
Species	Tonnes	% of world total	Species	Tonnes	% of world total
1. Kombu	3,908,952	12.5%	1. Kombu	4,580,056	10.0%
2. Pacific oyster	2,924,540	9.4%	2. Pacific oyster	3,944,042	8.6%
3. Silver carp	2,553,054	8.2%	3. Silver carp	3,473,051	7.6%
4. Chinese carp	2,104,450	6.7%	4. Chinese carp	3,447,474	7.5%
5. Common carp	1,815,598	5.8%	5. Common carp	2,718,277	5.9%
6. Bighead carp	1,256,839	4.0%	6. Manilla clam	1,693,012	3.7%
7. Manilla clam	1,148,393	3.7%	7. Bighead carp	1,636,623	3.6%
8. Japanese scallop	1,144,487	3.7%	8. Carassin(=Cyprin)	1,379,304	3.0%
9. Nori algae	919,122	2.9%	9. Japanese scallop	1,132,866	2.5%
10. Giant tiger shrimp	599,808	1.9%	10. Nile Tilapia	1,045,100	2.3%
11. Carassin(=Cyprin)	537,909	1.7%	11. Nori algae	1,010,963	2.2%
12. Wakame seaweed	531,390	1.7%	12. Atlantic salmon	883,558	1.9%
13. Eucheuma cottonii	522,763	1.7%	13. Labéo Roho	795,128	1.7%
14. Nile tilapia	519,565	1.7%	14. Catla catla	653,440	1.4%
15. Labéo Roho	472,728	1.5%	15. Eucheuma cottonii	604,600	1.3%
16. Atlantic salmon	465,245	1.5%	16. Cirrhinus mrigala	573,294	1.3%
17. Catla catla	396,330	1.3%	17. Giant tiger shrimp	571,497	1.3%
18. Cirrhinus mrigala	389,558	1.2%	18. Peking bream	511,730	1.1%
19. Rainbow trout	365,610	1.2%	19. Milkfish	461,857	1.0%
20. Milkfish	365,408	1.2%	20. Blue mussel	458,558	1.0%
21. Blue mussel	357,650	1.1%	21. Rainbow trout	448,141	1.0%
22. Peking bream	335,934	1.1%	22. Blood cockle	319,382	0.7%
23. Blood cockle	252,233	0.8%	23. Wakame seaweed	311,105	0.7%
24. Channel catfish	202,883	0.7%	24. Channel catfish	269,367	0.6%
25. Chinese mitten crab	41,516	0.1%	25. Chinese mitten crab	232,391	0.5%
Total 25 species	24,131,965	77.4%	Total 25 species	33,154,816	72.5%
Total for world	31,195,038	100%	Total for world	45,715,559	100%

Source : FAO Fishstat Database Version 2.3. 2002.

Although the number of species produced is fairly large, the top 25 in 1995 accounted for 77.4% of global production. In 2000, this same proportion was 72.5%. Kombu (brown algae or Japanese kelp) is the species with the highest production in the world, followed by the Pacific oyster, silver carp, Chinese carp and common carp. The order of the top five did not change between 1995 and 2000.

However, production of giant tiger shrimp fell from 10th to 17th spot in six years, especially due to growing environmental constraints for this species.

Production of Atlantic salmon rose from 16th to 12th rank world-wide, while rainbow trout slipped from 19th to 21st. Tilapia, for which all experts are predicting a phenomenal rise in production in coming years, moved up from 14th to 10th place. Finally, it should be noted that catfish production remained fairly stable, in 24th place.

1.1.5 Major producing countries

Some 158 countries produced at least one tonne of aquaculture products in 2000. Table 1.4 shows aquaculture production for the top 25 producing countries in 1995 and 2000. It should be noted that the cumulative production of these 25 countries represented 97% of world production in 1995 and 97.4% in 2000.

Table 1.4 The 25 largest aquaculture producing countries in 1995 and 2000

Production in 1995			Production in 2000		
Country	Tonnes	% of world total	Country	Tonnes	% of world total
1. China	20,018,273	64.2%	1. China	32,444,211	71.0%
2. India	1,686,346	5.4%	2. India	2,095,072	4.6%
3. Japan	1,389,613	4.5%	3. Japan	1,291,705	2.8%
4. Republic of Korea	1,017,254	3.3%	4. Philippines	1,044,311	2.3%
5. Philippines	919,810	2.9%	5. Indonesia	993,727	2.2%
6. Indonesia	743,092	2.4%	6. Thailand	706,999	1.5%
7. People's Democratic Republic of Korea	738,317	2.4%	7. Republic of Korea	697,866	1.5%
8. Thailand	559,504	1.8%	8. Bangladesh	657,121	1.4%
9. United States of America	413,411	1.3%	9. Vietnam	525,555	1.1%
10. Vietnam	389,069	1.2%	10. Norway	487,920	1.1%
11. Bangladesh	317,073	1.0%	11. People's Democratic Republic of Korea	467,700	1.0%
12. Chinese Province of Taiwan	286,668	0.9%	12. United States of America	428,262	0.9%
13. France	280,786	0.9%	13. Chile	425,058	0.9%
14. Norway	277,615	0.9%	14. Egypt	340,093	0.7%
15. Spain	223,965	0.7%	15. Spain	312,171	0.7%
16. Italy	214,725	0.7%	16. France	267,767	0.6%
17. Chile	206,266	0.7%	17. Chinese Province of Taiwan	256,385	0.6%
18. Malaysia	132,745	0.4%	18. Italy	216,525	0.5%
19. United Kingdom	93,838	0.3%	19. Malaysia	167,898	0.4%
20. Myanmar	71,700	0.2%	20. Brazil	153,558	0.3%
21. New Zealand	70,391	0.2%	21. United Kingdom	152,485	0.3%
22. Canada	**65,207**	**0.2%**	**22. Canada**	**123,297**	**0.3%**
23. Egypt	61,815	0.2%	23. Myanmar	98,912	0.2%
24. Brazil	46,202	0.1%	24. New Zealand	85,640	0.2%
25. Greece	32,644	0.1%	25. Greece	79,879	0.2%
Subtotal 25 countries	30,256,329	97.0%		44,520,117	97.4%
Total for world	31,195,038			45,715,559	

Source : FAO Fishstat Database Version 2.3. 2002.

The composition of the *Club of 25* changed very little between 1995 and 2000. However, the relative order of each member varied considerably. The top three producing countries remained the same: China, India and Japan. China is in a class of its own with 71% of world production in 2000. The Republic of Korea fell from 4th to 7th rank while the People's Democratic Republic of Korea slipped from 7th in 1995 to 11th spot in 2000. This situation is explained in part by the difficult economic conditions prevailing in the two Koreas during this period.

The United States and Italy were also unable to hold their own, dropping from 9th to 12th spot and from 16th to 18th place respectively. This decline is explained by virtually stagnant production during this period in both countries.

The United Kingdom and New Zealand also slipped a few spots despite a significant increase in their production.

The two leading salmon-producing countries in the world each climbed four ranks: Norway moved from 14th to 10th rank while Chile rose from 17th to 13th place. This improvement in Norway's status can be attributed to production of more than 210,000 tonnes in six years (primarily Atlantic salmon). Chile's performance is explained the fact that production more than doubled over this period, from 206,000 tonnes to more than 425,000 tonnes. In Chile, Atlantic salmon is also the main species produced.

The only country in Africa that has steadfastly promoted growth of its aquaculture sector is Egypt. Its production rose more than five-fold in six years and it rose from 23rd in the world to 14th. Brazil also improved its performance, rising from 24th to 20th position. This is attributable to an increase in national production of more than 232% in six years.

Finally, despite a sharp increase in production that still does not reflect its biophysical potential, Canada was just able to maintain its rank as the world's 22nd largest producer over this period. Production rose from 65,000 tonnes in 1995 to more than 123,000 tonnes in 2000, but accounted for only 0.27% of world production in 2000.

1.1.6 The special case of salmon

Since salmon is by far the largest aquaculture product in Canada, we found it useful to analyse the international context in greater detail for this species group. In 2000, only 11 countries shared world production of Atlantic salmon, the main salmon species available in the market (Table 1.5) and the 12th ranking species in the world.

In six years, Atlantic salmon production rose by more than 418,000 tonnes or 90% over 1995. When converted to an annual growth rate, this production rose by an average of 13.7% a year.

This production is largely dominated by Norway, with more than 49% of the 883,558 tonnes produced world-wide, followed by Chile, Scotland and Canada. These four producing countries alone total about 90% of global production. Denmark (Faeroe Islands), the United States, Ireland and Australia are next with emerging production of a few thousand tonnes. Finally, the group is completed by Iceland, France and Spain, which have just begun production.

Table 1.5 Volume, value and average price of world aquaculture production of Atlantic salmon, 1995-2000.

Country	Production (tonnes)					
	1995	1996	1997	1998	1999	2000
Norway	261,522	297,557	332,581	360,806	425,154	436,736
Chile	54,250	77,327	96,675	107 066	103,242	166,897
United Kingdom	70,322	83,344	99,422	110,917	126,686	128,959
Canada	33,674	36,475	51,015	49,475	61,990	68,395
Faeroe Islands	8,539	17,049	21,103	19,125	37,473	28,292
United States	14,075	13,906	18,005	14,507	17,739	22,395
Ireland	11,811	14,025	15,441	14,860	18,076	17,648
Australia	6,192	7,647	7,648	7,069	9,195	10,907
Iceland	2,591	2,832	2,513	2,742	2,900	2,593
France	894	800	950	760	750	502
Spain	695	726	851	798	618	226
TOTAL	**465,245**	**551,906**	**646,516**	**688,176**	**803,837**	**883,558**
	Value('000 US$)					
Norway	965,002	917,253	958,921	1,008,041	1,168,756	1,217,567
Chile	206,150	293,843	348,030	374,731	361,347	567,450
United Kingdom	183,097	188,766	325,706	332,751	380,058	386,877
Canada	156,373	151,594	172,746	181,607	239,922	255,695
United States	75,301	61,047	64,998	72,680	76,810	99,210
Faeroe Islands	41,265	63,908	69,460	64,275	119,509	93,364
Ireland	59,108	59,728	56,255	55,131	51,420	66,447
Australia	41,350	53,888	43,535	40,043	46,163	49,416
Iceland	11,660	9,912	9,298	10,420	10,730	9,853
France	6,095	4,400	3,748	3,040	3,000	2,259
Spain	3,018	2,850	2,881	2,713	2,163	904
TOTAL	**1,753,617**	**1,809,075**	**2,057,932**	**2,145,922**	**2,459,999**	**2,749,136**
	Value (US$/Kg)					
Australia	6.68	7.05	5.69	5.66	5.02	4.53
France	6.82	5.50	3.95	4.00	4.00	4.50
United States	5.35	4.39	3.61	5.01	4.33	4.43
Spain	4.34	3.93	3.39	3.40	3.50	4.00
Iceland	4.50	3.50	3.70	3.80	3.70	3.80
Ireland	5.00	4.26	3.64	3.71	2.84	3.77
Canada	4.64	4.16	3.39	3.67	3.87	3.74
Chile	3.80	3.80	3.60	3.50	3.50	3.40
Faeroe Islands	4.83	3.75	3.29	3.36	3.19	3.30
United Kingdom	2.60	2.26	3.28	3.00	3.00	3.00
Norway	3.69	3.08	2.88	2.79	2.75	2.79
Weighted avg. price ($/Kg)	**$3.77**	**$3.28**	**$3.18**	**$3.12**	**$3.06**	**$3.11**

Source : FAO Fishstat Database Version 2.3. 2002.

It should be noted for the leading group that from 1995 to 2000, production rose significantly: 70% in Norway, 207% in Chile, 83% in Scotland and 103% in Canada. Total world production of Atlantic salmon rose by 90% over six years, making it one of the species with the strongest growth in production.

The value of this product rose by about 57%, from US$1.75 billion to US$2.75 billion. This relatively modest increase in the total value of production, compared with the increase in volume, is explained by the declining average value per kilogram for salmon, from US$3.77 to US$3.11, a decline of 17%. The data in Table 1.3 quite clearly show that the countries with the largest production obtain the lowest value per kilogram for their product. Norway receives the lowest unit price. This corroborates the simple economic principle that rising production promotes a decline in unit price. This trend is almost certain to continue in coming years since the largest producing countries are expected to boost production further and since international competition will increase accordingly, especially in the European market between Scotland and Norway, and in the American market between Canada and Chile.

If we consider production of all major salmon species, adding production for coho and chinook salmon to the numbers for Atlantic salmon, we find that world production rose from 536,369 tonnes in 1995 to 1,008,840 tonnes in 2000 (Table 1.6). This world aquaculture production represented 91% of total landings in 1995 and more than 97% in 2000, since landings from commercial fisheries for these three species declined by 38% over this same period.

Table 1.6 ***World production (commercial fisheries and aquaculture) of Atlantic, Chinook and Coho salmon, 1995-2000***

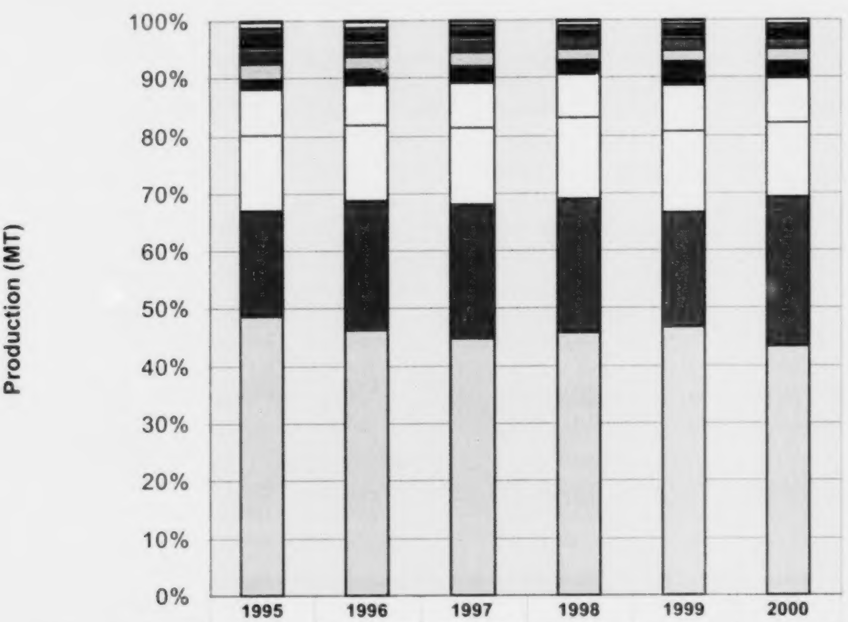
Origin	World production (tonnes)					
	1995	1996	1997	1998	1999	2000
Aquaculture	536,369	643,001	740,485	788,921	908,106	1,008,840
Commercial fisheries	50,297	45,451	32,094	34,037	28,816	31,111
Grand total	586,666	688,452	772,579	822,958	936,922	1,039,951
% from aquaculture	91%	93%	96%	96%	97%	97%

Source : FAO Fishstat Database Version 2.3. 2002.

By including these two new species, the list of producing countries grows by two members to add the production of Japan and New Zealand, which produce coho and chinook salmon respectively.

Figure 1.4 shows the relative share of world production for Atlantic, coho and chinook salmon in the 13 producing countries for 1995-2000.

It should be noted that despite an increase in production in all countries, the relative share of most remained fairly stable. This was true of Canada: despite an 85% increase in production (from 42,515 tonnes in 1995 to 78,495 tonnes in 2000), its relative share declined from 7.9% to 7.7% for the period. Only Norway seriously lost ground, from almost 49% to 43%, while Chile rose from 18% to 26%. With foreseeable development of deepwater production technology and offshore farming techniques, new countries will probably join this list. A prime example is South Africa, which is now developing this type of production.



	1995	1996	1997	1998	1999	2000
■Spain	0,1%	0,1%	0,1%	0,1%	0,1%	0,0%
□France	0,2%	0,1%	0,1%	0,1%	0,1%	0,0%
□New Zealand	0,9%	1,0%	0,6%	0,7%	0,6%	0,6%
▨Australia	1,2%	1,2%	1,0%	0,9%	1,0%	1,1%
■Japan	2,5%	1,3%	1,3%	1,1%	1,2%	1,3%
□Iceland	0,5%	0,4%	0,3%	0,3%	0,3%	0,3%
▨Ireland	2,2%	2,2%	2,1%	1,9%	2,0%	1,7%
□USA	2,6%	2,2%	2,4%	1,8%	2,0%	2,2%
■Faeroe Islands	1,6%	2,7%	2,8%	2,4%	4,1%	2,8%
□Canada	7,9%	7,1%	7,7%	7,4%	8,0%	7,8%
□Scotland	13,1%	13,0%	13,4%	14,1%	14,0%	12,8%
▨Chile	18,4%	22,5%	23,1%	23,3%	19,8%	26,1%
□Norway	48,7%	46,3%	44,9%	45,7%	46,8%	43,3%

Years

Figure 1.4 ***Relative share of world production of Atlantic, coho and chinook salmon for all producing countries, 1995-2000***

1.2 REGIONAL TRENDS

This section details major regional trends (by continent) for aquaculture production in terms of product volume and the main aquaculture species.

Aquaculture is very heavily dominated by Asian production in general and by China in particular. In 2000, China's production accounted for more than 71% of world production, while that of all other Asian countries combined accounted for about 20% (Figure 1.5). Europe ranks second among continents, but with only 4.4% of total production. South America, dominated primarily by Chile, which alone represents some 1.6% of the total, roughly the equivalent of North America, which accounts for 1.5%. Africa counts for less than 1% while Oceania represents just 0.3% of world production.

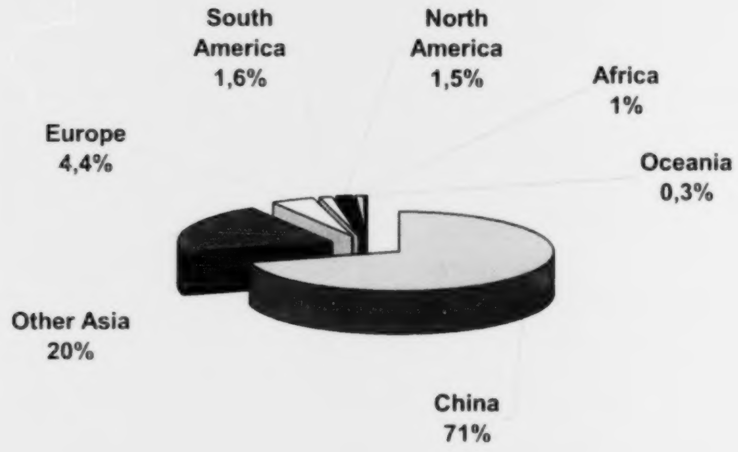


Figure 1.5 ***Relative share of world production for China, other Asian countries, South America, North America, Africa and Oceania, 2000***

1.2.1 Asia

Asian aquaculture production rose by 47% over the past six years, from more than 28 million to almost 42 million tonnes (Table 1.7). Asia accounts for more than 91% of world aquaculture production. This production is largely freshwater fish (45%), mainly carp, followed by aquatic plants (24%) and shellfish (23%).

China's production is also largely in freshwater fish (45%), followed by shellfish (26%) and aquatic plants (24%). In China as well as the rest of the continent, production of diadromous fish, saltwater fish and other aquatic animals is just emerging, since each accounts for less than 2% of the Asian total.

Table 1.7 Aquaculture production for Asia and China, 1995-2000

Types of products	Production (tonnes)						
	1995	1996	1997	1998	1999	2000	% in 2000
ASIA							
Freshwater fish	12,328,376	14,070,902	15,492,249	16,360,061	17,734,825	18,763,124	45.0%
Aquatic plants	6,722,110	7,052,870	7,079,694	8,468,978	9,492,016	10,073,581	24.1%
Shellfish	7,295,018	7,545,032	7,596,367	8,041,516	9,015,006	9,695,117	23.2%
Crustaceans	933,904	966,249	1,014,410	1,139,408	1,303,370	1,473,437	3.5%
Diadromous fish	627,074	677,964	683,424	698,236	750,722	799,766	1.9%
Saltwater fish	473,713	495,289	601,558	661,824	700,086	782,980	1.9%
Aquatic animals	55,195	61,978	81,576	109,615	132,389	136,464	0.3%
TOTAL ASIA	28,437,385	30,872,280	32,551,275	35,481,636	39,130,413	41,726,469	100.0%
CHINA							
Freshwater fish	9,228,640	10,710,191	12,011,379	12,809,048	13,727,527	14,586,486	45.0%
Shellfish	6,162,731	6,406,595	6,510,978	7,002,498	7,934,771	8,607,050	26.5%
Aquatic plants	4,162,620	4,493,925	4,714,690	6,276,575	7,254,290	7,863,540	24.2%
Crustaceans	181,880	236,309	326,619	452,145	547,569	707,095	2.2%
Saltwater fish	144,957	182,155	254,979	306,697	338,805	426,957	1.3%
Diadromous fish	120,000	147,316	167,208	163,098	164,484	160,740	0.5%
Aquatic animals	17,445	32,004	44,460	61,881	76,731	92,343	0.3%
TOTAL CHINA	20,018,273	22,208,495	24,030,313	27,071,942	30,044,177	32,444,211	100.0%
TOTAL FOR WORLD	31,195,038	33,892,260	35 837,273	39,062,244	42,994,417	45,715,559	
% Asia	91%	91%	91%	91%	91%	91%	
% China	64%	66%	67%	69%	70%	71%	

Source : FAO Fishstat Database Version 2.3. 2002.

The 14 most common aquaculture species in Asia represented 77% of total production in 2000, more than 32 million tonnes (Table 1.8). The species with the highest production is kombu (Japanese kelp), an aquatic plant in the brown algae family (varech). This plant is actually the world's top aquaculture species, followed by Pacific oysters and carp (silver, Chinese and common).

It should be noted that only nori algae is produced primarily outside China. All other species are dominated by China's production, including Japanese scallops, with 919,000 tonnes produced in China and about 210,000 tonnes in Japan.

Asian aquaculture production is primarily extensive and integrated into existing agricultural production and fisheries systems. The FAO reports that all countries in the region have vast undeveloped potential for growth (FAO, 2000), although rural aquaculture has become much more developed in countries such as China and India in recent years, as shown by the data presented in Table 1.4.

Table 1.8 The 14 most common aquaculture species in Asia

Species	Production (tonnes)						
	1995	1996	1997	1998	1999	2000	% in 2000
1. Kombu (brown algae)	3,908,952	4,451,570	4,401,931	4,393,199	4,917,788	4,580,056	11.0%
2. Pacific oyster	2,724,008	2,721,300	2,771,960	3,228,284	3,390,148	3,741,499	9.0%
3. Silver carp	2,508,890	2,834,082	3,188,134	3,272,873	3,336,360	3,404,717	8.2%
4. Herbivorous carp (Chinese)	2,100,156	2,436,268	2,710,393	2,982,905	3,259,692	3,378,643	8.1%
5. Other aquatic plants	641,725	478,513	471,920	1,952,999	2,401,319	3,262,396	7.8%
6. Common carp	1,631,270	1,848,620	2,023,810	2,215,330	2,401,848	2,498,712	6.0%
7. Freshwater fish nie*	1,475,873	1,501,283	1,320,161	1,484,376	1,722,812	2,019,330	4.8%
8. Manilla clam	1,085,443	1,113,181	1,271,941	1,422,439	1,813,597	1,634,690	3.9%
9. Bighead carp	1,249,910	1,412,851	1,548,428	1,580,230	1,604,599	1,630,595	3.9%
10. Other saltwater shellfish	1,139,992	1,284,037	1,134,728	1,108,723	1,257,125	1,590,671	3.8%
11. Cyprinids	537,555	692,905	862,166	1,035,602	1,239,197	1,378,751	3.3%
12. Japanese scallop	1,144,374	1,265,228	1,256,199	855867	928,724	1,132,665	2.7%
13. Nori algae	919,122	856,588	861,231	960 ,048	1,034,929	1,010,963	2.4%
14. Nile tilapia	485,513	583,677	689,568	692,795	754,071	853,526	2.0%
Total 14 species	21,554,778	23,482,099	24,514,567	27,187,668	30,064,208	32,119,214	77.0%
Total Asia	28,437,385	30,872,280	32,551,275	35,481,636	39,130,413	41,726,469	100.0%

Source : FAO Fishstat Database Version 2.3. 2002.
*nie : not included elsewhere

Increasingly, however, China is intensifying aquaculture systems. These more intensive production methods, based on the use of artificial feed, are more common in coastal provinces where small-scale operations account for 60% of production, while in the poorest, most isolated provinces, traditional integrated systems essentially based on natural fertilization of stocks are still predominant (FAO, 2000). In India, aquaculture is still based on extensive to semi-intensive production methods.

Quite clearly, rural aquaculture is gaining increasing recognition as an effective means for improving the living conditions of poor populations. Many governments and development organizations also place great importance on this sector in the Asian region.

The FAO also reports that aquaculture in Asia still faces a number of problems, especially access to technology and financing, the environmental impact of production, and diseases affecting aquaculture stocks.

According to the FAO, the leading constraints that need to be addressed, notably through exhaustive R&D programs, are:

- the adoption of aquaculture by rural households;
- development and use of technology designed to ensure sustainable upgrading of stocks, introduction of sea-ranching programs, development of efficient, affordable water recirculation systems, deep-water fish cages and genetic growth enhancement;
- use of integrated systems designed to enhance environmental performance;
- improved management of aquatic animal health;
- improved nutritional performance in aquaculture; and
- improved product quality and safety.

These constraints are not necessarily limited to Asia. Many are faced by other countries in other regions of the world.

1.2.2 Europe

Europe is the second largest producing continent by volume for aquaculture production, but production only amounted to two million tonnes in 2000 (Table 1.9). With production of 1.6 million tonnes in 1995, this continent therefore posted growth of about 28% in production over a period of six years. Despite this increase, Europe is losing market share, down from 5.1% of world production in 1995 to 4.4% in 2000.

Diadromous fish (essentially Atlantic salmon, rainbow trout and European eels) account for 46% of European production, followed by shellfish and freshwater fish.

Table 1.9 ***Aquaculture production for Europe (including countries of the former USSR), 1995-2000***

Types of products	Production (tonnes)						
	1995	1996	1997	1998	1999	2000	% in 2000
Diadromous fish	632,089	705,317	776,618	826,403	926,478	930,214	45.8%
Shellfish	693,890	716,805	711,976	819,868	823,476	768,692	37.9%
Freshwater fish	206,841	187,551	183,209	189,652	205,577	208,344	10.3%
Saltwater fish	42,283	50,418	61,742	79,293	101,730	115,348	5.7%
Aquatic plants	11,660	5,472	11,657	6,095	6,020	6,028	0.3%
Crustaceans	263	319	394	297	246	209	0.0%
Aquatic animals	<0.5	<0.5	74	30	3	-	0.00%
TOTAL Europe	1,587,026	1,665,882	1,745,670	1,921,638	2,063,530	2,028,835	100.0%
TOTAL FOR WORLD	31,195,038	33,892,260	35,837,273	39,062,244	42,994,417	45,715,559	
% Europe	5.1%	4.9%	4.9%	4.9%	4.8%	4.4%	

Source : FAO Fishstat Database Version 2.3. 2002.

If the leading 16 species (or groups of similar species) are combined, this represents about 97% of Europe's production (Table 1.10). Atlantic salmon dominates this list with more than 30% of production (mostly from Norway and Scotland), followed by blue mussels (from Spain, the Netherlands and France) with 21% of production and rainbow trout, representing 14% of European aquaculture products (primarily from saltwater production in Norway and freshwater production in Italy, France, Denmark and Spain).

Some species posted very strong growth in Europe from 1995 to 2000. This is true of gilthead seabream and European sea bass, usually produced in the same facilities. Production of these species almost tripled, from 34,502 tonnes in 1995 to 99,926 tonnes in 2000, and originated mainly from Greece, Italy, Spain and, to a lesser extent, France.

The European context determining the growth of aquaculture production has been dominated over the past decade by increasing environmental constraints and concerns related to protection of public health. Pressure from environmental groups and the general public was favourably received by national governments and the Commission of European Communities (CEC). The latter, while acknowledging that aquaculture makes a significant contribution to the supply of fish and provides replacement jobs in many regions dependent on fisheries that are often in decline, stipulated in its recent *Green Paper on the future of the Common Fisheries Policy* that aquaculture must effectively meet the challenges arising from environmental requirements and health protection (CEC, 2001b).

In its timeline for implementing the *Common Fisheries Policy* reforms, the CEC recognized its role to create the best possible conditions for sustainable development of European aquaculture (CEC, 2002a). To this end, the CEC decided to focus on three areas of intervention: research, establishment of a suitable environment for development, and establishment of common health standards.

Table 1.10 ***The 16 most common aquaculture species in Europe (including countries of the former USSR), 1995-2000***

Species	Production (tonnes)						
	1995	1996	1997	1998	1999	2000	% in 2000
1. Atlantic salmon	356,400	416,358	473,123	510,019	611,671	614,964	30.3%
2. Blue mussel	348,088	395,936	388,320	485,386	479,809	435,013	21.4%
3. Rainbow trout	259,628	270,395	284,511	295,710	289,269	289,134	14.3%
4. Pacific oyster	149,139	156,145	153,174	144,020	145,545	140,582	6.9%
5. Common carp	139,770	130,142	125,274	128,758	134,520	137,725	6.8%
6. Mediterranean mussel	111,462	103,501	105,193	116,493	121,261	115,334	5.7%
7. Gilthead seabream	17,354	23,304	29,139	37,626	49,601	58,041	2.9%
8. Manilla clam	60,120	40,531	40,376	49,894	51,976	55,858	2.8%
9. European bass	17,148	19,325	24,079	30,168	37,737	41,885	2.1%
10. Silver carp	33,940	28,386	28,545	31,482	34,614	37,732	1.9%
11. European eel	6,918	8,614	8,696	9,792	10,536	10,617	0.5%
12. Sea trout	4,012	5,477	4,790	4,775	6,500	6,938	0.3%
13. Freshwater fish nie*	6,417	6,146	6,766	5,518	7,938	6,668	0.3%
14. Bighead carp	6,928	5,577	4,878	4,905	4,392	6,025	0.3%
15. European flat oyster	5,574	5,698	5,412	5,669	6,195	5,913	0.3%
16. Cyprinids	4,770	2,690	3,785	5,146	4,939	5,578	0.3%
Total 16 species	1,527,668	1,618,225	1,686,061	1,865,361	1,996,503	1,968,007	97.0%
Total for Europe	1,587,026	1,665,882	1,745,670	1,921,638	2,063,530	2,028,835	100.0%

Source : FAO Fishstat Database Version 2.3. 2002.
*nie: not included elsewhere

The CEC has developed an intervention strategy designed to ensure a supply of healthy products to consumers, promote environmentally friendly activities and create jobs, especially in regions dependent on traditional fisheries.

To implement its strategy, the CEC plans in coming years to introduce measures and programs designed to:

- Create a set of common standards for recognition and supervision of the development of *organic aquaculture*; current EU legislation on organic agriculture contains no special or specific provisions on aquaculture;
- Adapt EU legislation on fish diseases to recent growth in production and advances in technology and management systems, as well as new diagnostic techniques;
- Introduce new regulations on aquaculture fish wellness, organic needs and health to improve the public perception of intensive aquaculture and reduce the effect on the environment in some cases;
- Reduce water pollution due to aquaculture (reduced eutrophization); and
- Prevent any introduction or escape of exotic species.

For more detailed information regarding Spain, France, Norway, United Kingdom and the European Union see Section II.

1.2.3 South America

Aquaculture production for South America was about 725,514 tonnes in 2000, an increase of 77% over the 409,516 tonnes produced in 1995. This continent's relative share rose from 1.3 to 1.6% of world production (Table 1.11). In 2000, this production was dominated by diadromous fish (essentially Atlantic salmon, rainbow trout and coho salmon), which accounted for almost half the total and produced mostly in Chile. Freshwater fish follow with a relative share of 24%. The third product is crustaceans, with more than 96,000 tonnes, or 13.3% of the continent's production.

Table 1.11 Aquaculture production for South America, 1995-2000

Types of products	Production (tonnes)						
	1995	1996	1997	1998	1999	2000	% in 2000
Diadromous fish	154,233	207,778	259,815	269,956	242,760	357,623	49.3%
Freshwater fish	61,418	91,072	110,177	125,430	158,633	176,207	24.3%
Crustaceans	124,726	127,216	155,844	169,914	156,407	96,734	13.3%
Shellfish	19,512	24,177	30,998	42,510	55,777	58,440	8.1%
Aquatic plants	49,225	105,471	102,928	68,671	31,491	33,642	4.6%
Saltwater fish	38	168	281	434	2,724	2,171	0.3%
Aquatic animals	364	458	555	603	608	697	0.1%
Total South America	409,516	556,340	660,598	677,518	648,400	725,514	100.0%
Total for world	31,195,038	33,892,260	35,837,273	39,062,244	42,994,417	45,715559	
% South America	1.3%	1.6%	1.8%	1.7%	1.5%	1.6%	

Source : FAO Fishstat Database Version 2.3. 2002.

Table 1.12 shows production for the 12 most common aquaculture species in South America from 1995 to 2000. These 12 species represent more than 94% of the total. The leading species by volume is Atlantic salmon, with some 167,000 tonnes in 2000, an increase of 207% over 1995. All this production originates from Chile, as does that of coho salmon, the fourth leading species on the continent. Production of rainbow trout has also experienced strong growth, with an increase of almost 50% over six years. The growth in this product is not the result of massive development of land-based sites, but rather the use of sea cages, primarily in Chile.

The only two species that posted a decline in production over the period in question were whiteleg shrimp and Gracilaria seaweeds The first can be attributed to a drop of more than half in production of this species of shrimp, especially in Ecuador, due to a major disease problem. In the second case, production of Gracilaria seaweeds in Chile fell to 33,000 tonnes after peaking at 105,000 tonnes in 1996.

In response to the existing social and economic context, aquaculture has grown in South America primarily as an important source for foreign currency since it essentially targets export markets. Although development of industrial aquaculture has played an important role in job creation in Chile and Ecuador, the region's real potential appears to lie in the expansion of small and midsized non-industrial production units that depend largely on government support. Hernandez-Rodriguez *et al.* (2001) state that an important role for government is to contribute to a significant improvement in the sector's competitiveness through the development of information systems and the dissemination of this information to aquaculture operators and investors.

Table 1.12 The 12 most common aquaculture species in South America, 1995-2000

Species	Production (tonnes)						
	1995	1996	1997	1998	1999	2000	% in 2000
1. Atlantic salmon	54,250	77,327	96,675	107,066	103,242	166,897	23.0%
2. Whiteleg shrimp	114,368	115,749	140,753	154,202	143,136	95,427	13.2%
3. Rainbow trout	55,575	63,110	88,945	85,816	62,962	94,708	13.1%
4. Coho salmon	44,037	66,988	73,408	76,954	76,324	93,419	12.9%
5. Common carp	16,977	24,189	35,933	34,299	50,179	53,396	7.4%
6. Tilapia nie*	26,055	28,311	33,556	41,351	46,125	49,200	6.8%
7. Gracilaria seaweeds	49,225	105,471	102,928	68,671	31,491	33,642	4.6%
8. Freshwater fish nie*	1,646	7,814	5,432	16,748	22,420	23,875	3.3%
9. Chilean mussel	5,595	6,064	8,635	11,911	16,203	23,477	3.2%
10. Fan scallop	8,695	10,180	11,793	17,495	22,253	21,295	2.9%
11. Piaractus brachypomus	3,183	6,154	11,610	11,811	13,014	14,997	2.1%
12. Nile tilapia	3,817	3,378	3,328	4,185	7,844	13,143	1.8%
Total 12 species	383,423	514,735	612,996	630,509	595,193	683,476	94.2%
Total for South America	409,516	556,340	660,598	677,518	648,400	725,514	100.0%

Source : FAO Fishstat Database Version 2.3. 2002.
*nie : not included elsewhere

The availability of sites and development of aquaculture focused on export markets poses no problem. For example, only 16% of suitable sites in this region for growing shrimp are actually used. The FAO also estimates that additional volume of 2 to 3 million tonnes of saltwater product will be needed to meet projected consumer demand in South America in 2010.

Growth of shrimp production remains closely linked to environmental constraints (impact of production, deforestation, climate change, etc.), techniques constraints (control of production cycles) and aquatic animal health constraints.

The constraints affecting production of salmonids are more related to economics and markets: major price fluctuations, repeated economic recessions affecting major export markets in Asia, charges of dumping against Chile, as well as continuing significant losses of inventory related to disease.

To achieve its full potential, this region must still overcome many internal and external challenges. In terms of policies promoting aquaculture development, a general trend appears to be emerging of sharp cutbacks in direct government assistance, and a shift toward creation of a legal, regulatory and administrative environment that facilitates development of this sector. Access to required capital still remains very difficult (Hernandez-Rodriguez *et al.*, 2001). At the international level and to remain competitive, South American companies, like their competitors, must comply with international rules governing trade, health and sustainable development, such as HACCP (Hazard Analysis Critical Control Point) and the FAO Code of Conduct for Responsible Fisheries.

For more detailed information regarding Chile, see Section 2.2.

1.2.4 North America

North America also includes Central American countries and all the Caribbean islands because we have used the FAO geographic classification.

Compared with the other continents and for the period from 1995 to 2000, North American production posted the weakest growth with a rate of 25% over six years. Although production of freshwater fish and diadromous fish posted respectable growth of 45% and 60% respectively, volumes of shellfish products declined by 22% and those of crustaceans remained fairly stable (Table 1.13).

This decline in shellfish production essentially can be traced to a very sharp drop in production of American oysters in the United States: volumes of this species fell from 73,991 tonnes in 1995 to 10,472 tonnes in 2000. This very specific collapse in aquaculture production was due to sharply falling prices paid to producers.

The relative share of total North American production shrank somewhat over the period in question, from 1.8% in 1995 to 1.5% in 2000.

Table 1.13 ***Aquaculture production for North America (including Central America and the Caribbean), 1995-2000***

Types of products	Production (tonnes)						
	1995	1996	1997	1998	1999	2000	% in 2000
Freshwater fish	255,586	290,103	326,757	343,596	373,242	371,272	53.2%
Diadromous fish	92,437	96,358	113,357	112,377	137,427	147,544	21.1%
Shellfish	143,373	120,276	131,269	134,506	148,131	111,906	16.0%
Crustaceans	66,508	59,538	69,224	73,770	74,519	66,842	9.6%
Saltwater fish	1,046	727	263	251	271	280	0.0%
Aquatic animals	50	63	84	62	71	75	0.0%
Aquatic plants	1	1	-	-	14	-	0.0%
Total for North America	559,001	567,066	640,954	664,562	733,675	697,919	100.0%
TOTAL FOR WORLD	31,195,038	33,892,260	35,837,273	39,062,244	42,994,417	45,715,559	
% North America	1.8%	1.7%	1.8%	1.7%	1.7%	1.5%	

Source : FAO Fishstat Database Version 2.3. 2002.

The 19 leading species in North America, Central America and the Caribbean in 2000 represented more than 97% of total production (Table 1.14).

The most common species in this region remains channel catfish (in the United States only), followed by Atlantic salmon (primarily in Canada) and whiteleg shrimp (mostly in Mexico). Silver carp (in Cuba only), quahog (in the United States only) and Nile tilapia (mainly in Costa Rica) are the species with the strongest growth.

Conversely, American oysters and red swamp crayfish, both produced only in the United States, are the two species that posted a decline in production. The decline in crayfish is due primarily to the strength of the US dollar and very strong competition from substitute products in the domestic American market and international markets, especially from China.

Table 1.14 ***The 19 most common aquaculture species in North America (including Central America and the Caribbean), 1995-2000***

Species	Production (tonnes)						
	1995	1996	1997	1998	1999	2000	% in 2000
1. Channel catfish	202 778	214 410	238 161	256 073	270 664	269 295	38.6%
2. Atlantic salmon	47 749	50 381	69 020	63 982	79 729	90 790	13.0%
3. Whiteleg shrimp	27 371	24 431	31 856	43 365	43 437	46 000	6.6%
4. Pacific oyster	42 565	36 997	31 277	39 270	40 134	44 821	6.4%
5. Rainbow trout	27 577	26 641	28 215	28 970	35 799	35 130	5.0%
6. Silver carp	9 924	15 552	21 808	25 696	31 987	30 000	4.3%
7. Quahog	10 942	5 540	17 992	19 943	26 517	23 985	3.4%
8. Blue mussel	9 552	12 135	12 915	16 214	18 641	23 535	3.4%
9. Freshwater fish nie*	8 316	16 607	18 291	18 865	21 077	20 630	3.0%
10. Tilapia nie*	13 973	18 060	22 090	13 757	15 645	16 421	2.4%
11. American oyster	76 450	59 514	65 147	55 734	57 522	14 879	2.1%
12. Nile tilapia	3 868	3 798	3 930	10 322	12 755	14 533	2.1%
13. Penaeid prawn nie*	9 828	11 301	11 082	9 539	9 531	10 548	1.5%
14. Common carp	3 611	8 933	8 718	7 103	7 477	8 845	1.3%
15. Chinook salmon	8 073	8 393	4 326	6 579	8 800	8 000	1.1%
16. Red swamp crayfish	26 605	21 380	22 592	17 216	19 459	7 713	1.1%
17. Trout nie*	4 429	6 592	5 910	5 962	6 581	6 407	0.9%
18. Notemigonus crysoleucas	9 883	9 457	9 040	7 434	7 434	6 330	0.9%
19. American bass, hybrid	3 772	3 561	3 810	4 257	4 415	5 052	0.7%
Total 19 species	543 494	550 122	622 370	646 024	713 189	677 862	97.1%
Total North America, Latin America and Caribbean	559 001	567 066	640 954	664 562	733 675	697 919	100.0%

Source : FAO Fishstat Database Version 2.3. 2002.
nie: not included elsewhere

In 2000, the United States and Canada accounted for 61% (428,262 tonnes) and 18% (123,297 tonnes) respectively of total regional production. Mexico followed with 7.8% (53,802 tonnes, mostly whiteleg shrimp) and Cuba with 7.6% (52,700 tonnes, almost totally silver carp and other freshwater fish).

In most countries with significant aquaculture production, the government provides considerable institutional support for the development of aquaculture (Olin, 2001; Hernandez-Rodriguez *et al*, 2001). This is especially true of the Government of Canada, which has a *National Aquaculture Policy* (DFO, 2002), and provincial governments in Canada are directly involved in managing the public domain and providing legal and regulatory supervision of the sector. Without setting a specific growth target for Canada's aquaculture sector, the Government of Canada believes that this policy reflects the major benefits to society provided by aquaculture and makes sustainable development of this sector a major federal priority.

In the United States, the Department of Commerce established an *Aquaculture Policy* in 1999 to promote sustainable development of the sector and of a highly competitive industry. This policy calls for expansion of the sector, especially in the value of production, from US$870 million in 2000 to US$5 billion in 2025. It also calls for the creation of more than 320,000 new jobs during this period.

There are many constraints to achieving this potential, primarily availability of the natural resources needed for production (access to production sites), access to effective health services from aquaculture organizations (adequate veterinary services and availability of required therapeutic products), an enabling legal and regulatory environment to promote growth (updating legislation and regulations to meet current sector needs), and wavering general public support.

For more detailed information regarding United States of America, see Section 2.4.

1.2.5 Africa

African production almost quadrupled between 1995 and 2000, from 104,620 tonnes to 399,390 tonnes, boosting the continent's relative share of world production from 0.3% à 0.9% (Table 1.15). More than 70% of this production consists of freshwater fish and 25% of saltwater fish. The only group that declined over the period was shellfish production, due mainly to falling production of Mediterranean mussels in South Africa.

Table 1.15 Aquaculture production for Africa and Egypt, 1995-2000

Types of products	Production (tonnes)						
	1995	1996	1997	1998	1999	2000	% in 2000
Freshwater fish	74,657	87,243	94,348	137,147	214,586	281,344	70.4%
Saltwater fish	19,262	24,459	22,674	37,524	49,913	101,028	25.3%
Aquatic plants	4,327	3,439	3,112	5,153	7,160	7,177	1.8%
Crustaceans	1,911	2,896	3,210	3,297	3,929	5,425	1.4%
Shellfish	2,988	2,384	3,379	3,527	3,004	2,451	0.6%
Diadromous fish	1,475	1,090	1,371	1,977	1,506	1,965	0.5%
Aquatic animals	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0%
TOTAL for Africa	104,620	121,511	128,094	188,625	280,098	399,390	100.0%
TOTAL FOR WORLD	31,195,038	33,892,260	35,837,273	39,062,244	42,994,417	45,715,559	
% Africa	0.3%	0.4%	0.4%	0.5%	0.7%	0.9%	
Production for Egypt	61,815	75,837	73,454	139,389	226,276	340,093	
% Egypt/Africa	59%	62%	57%	74%	81%	85%	

Source : FAO Fishstat Database Version 2.3. 2002.

Africa's production is very heavily dominated by one country, Egypt. This country's production rose from 61,815 tonnes in 1995 to 340,093 tonnes in 2000, an increase of 450%. In 2000, Egypt's production accounted for 85% of the total for Africa. Nile tilapia represented 46% of Egypt's production in 2000 with 157,425 tonnes, striped mullet 24% with 80,530 tonnes and Chinese carp 20% with 66,231 tonnes.

In Africa, nine main species accounts for more than 93% of the continent's production, and Egypt's production is the overriding determinant (Table 1.16). Nile tilapia, striped mullet and Chinese carp continue to dominate this list. These nine species experienced strong growth in six years, except common carp, for which production declined slightly, as it slipped from second to fourth place. Once again, Egypt's dominant impact explains this change, as production of this species dropped slightly in that country during the period in question.

Saltwater fish production in Africa consists almost entirely of striped mullet, European sea bass and gilthead seabream. Production of these three species posted major growth during the period studied, primarily in Egypt, but to a lesser extent in Morocco and Tunisia as well. Although these are saltwater fish, these species are raised in the vast majority of cases in brackish water.

Table 1.16 The nine most common aquaculture species in Africa, 1995-2000

Species	Production (tonnes)						
	1995	1996	1997	1998	1999	2000	% in 2000
1. Nile tilapia	25,230	31,667	33,321	55,946	108,093	161,958	40.6%
2. Striped mullet	14,703	20,396	16,519	28,639	43,196	80,827	20.2%
3. Herbivorous (Chinese) carp	2,038	2,610	15,781	38,638	51,607	66,531	16.7%
4. Common carp	23,959	24,620	13,762	15,297	25,752	19,590	4.9%
5. Freshwater fish nie*	2,302	1,705	2,259	3,332	12,162	11,324	2.8%
6. European sea bass	1,528	1,604	3,381	4,726	3,344	10,483	2.6%
7. Gilthead seabream	1,812	2,414	2,738	4,131	3,332	9,681	2.4%
8. Eucheuma PPS	4,000	3,000	3,000	5,000	7,000	7,000	1.8%
9. Giant tiger shrimp	1,743	2,705	3,062	3,141	3,713	5,225	1.3%
Total 9 species	77,315	90,721	93,823	158,850	258,199	372,619	93.3%
Total Africa	104,620	121,511	128,094	188,625	280,098	399,390	100.0%

Source : FAO Fishstat Database Version 2.3. 2002.
*nie: not included elsewhere

The African continent is actually divided into two regions with very different opportunities and constraints for the development of aquaculture: sub-Saharan Africa and Arab Africa.

Machena and Moehl (2001) report major development potential in sub-Saharan Africa, especially for the regional domestic market (food security objective), although consumption of fisheries products per capita has declined in the past decade, from 9 to 6 kg/inhabitant/year.

Non-industrial extensive and intensive production systems are the key to initial potential increases in production. Industrial-scale operations may also play an important role. The region's comparative advantages include water resources and under-developed sites, availability of a large, low-cost work force, fairly high demand for fish, and a climate that can support year-round growth of stock.

This potential can only be achieved, however, if the following constraints are overcome:

- development of a positive perception of aquaculture, especially among farmers and others interested in the possibility of promoting integration of aquaculture into existing stock systems in agriculture or aquaculture;
- lack of strong government policies to promote development of the sector at the national level;
- introduction of effective public institutions;
- limited availability of food inputs for production systems;

- lack of measures to foster financial participation by private investors; and
- difficulty in accessing financing for projects on a commercial scale (as opposed to family businesses which appear to face no problems obtaining financing).

As stated earlier, Egypt accounts for the vast majority of production in North Africa. The country established a 15-year national strategy to expand the availability of fisheries products. This strategy promotes growth in fish consumption from the current level of 10 kg/inhabitant/year to 13 kg/inhabitant/year. Consistent with this strategy, aquaculture has been identified as the best tool for narrowing the growing gap between the availability of seafood and domestic demand. The rapid, if not explosive, growth of aquaculture in Egypt is a result of this decision (El Gamal, 2001). Starting with less production than Canada in 1995, in the year 2000 produced about three times the production of Canada for the same year.

This rapid increase in Egypt's production also assisted the development of infrastructure to support the industry and is now driving a rapid transition from semi-intensive to intensive production methods, particularly in response to fierce competition for resources, especially water. This last resource is the main limitation on any aquaculture development in North Africa. To establish a system for fair allocation of this resource to various users, the Egyptian government allows only drainage water from farmland to be used for aquaculture.

In the medium term, seawater aquaculture is considered an important approach to expansion of African aquaculture. Production of species such as seabream and sea bass should increase and target export markets, particularly Europe (Machena and Moehl, 2001; El Gamal, 2001). Two major constraints that may hinder this growth are the availability of young stock (need to develop a network of fish hatcheries) and nutrients (need to introduce mills to supply competitively-priced feed).

1.2.6 Oceania

The Oceania region includes Australia, New Zealand and all the surrounding Pacific islands such as French Polynesia, Papua-New Guinea, Kiribati and New Caledonia, to name just a few.

Aquaculture production for this region grew by 40% between 1995 and 2000, from more than 99,000 tonnes to slightly less than 140,000 tonnes (Table 1.17). However, the region's relative share of world aquaculture remained stable, at 0.3%. Unlike the other continents, this production is dominated by shellfish, which account for more than 68% of landings. Diadromous fish follow at 14%.

New Zealand and Australia are the two main producing countries, with 61% and 29% of production, respectively, in 2000. It should be noted that New Zealand's relative share declined by 10% over the period, primarily to the benefit of Australia, where production rose from 23% to 29% of the regional total.

Table 1.17 Aquaculture production for Oceania, 1995-2000

Types of products	Production (tonnes)						
	1995	1996	1997	1998	1999	2000	% in 2000
Shellfish	75,516	79,524	84,416	98,719	99,823	95,576	68.5%
Diadromous fish	13,443	16,791	14,933	16,028	17,602	20,004	14.3%
Aquatic plants	5,248	9,480	7,376	6,148	10,905	10,020	7.2%
Saltwater fish	1,932	2,018	2,189	5,194	6,400	7,856	5.6%
Crustaceans	3,067	3,022	3,037	3,495	4,846	5,073	3.6%
Freshwater fish	279	342	728	679	724	903	0.6%
TOTAL Oceania	99,485	111,177	112,679	130,263	140,300	139,432	100.0%
TOTAL FOR WORLD	31,195,038	33,892,260	35,837,273	39,062,244	42,994,417	45,715,559	
% Oceania	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	
Production for New Zealand	70,391	74,800	75,850	93,807	91,650	85,640	
% NZ/Oceania	71%	67%	67%	72%	65%	61%	
Production for Australia	22,395	25,323	26,637	28,106	33,729	39,909	
% Australia/Oceania	23%	23%	24%	22%	24%	29%	

Source : FAO Fishstat Database Version 2.3. 2002.

Table 1.18 shows production for the 12 top species in Oceania. In 2000, these represented more than 98% of regional production. This list is dominated by the New Zealand mussel (raised only in New Zealand), which accounts for almost 55% of total production with a volume of 76,000 tonnes. A distant second is Atlantic salmon (raised only in Australia) and Pacific oysters (grown almost exclusively in Australia and New Zealand). Algae of the genus *Eucheuma* in turn represent about 7.2% of regional production and the vast majority comes from Kiribati.

Other species form a group of emerging products: southern bluefin tuna, chinook salmon, Australian oysters, giant tiger shrimp, rainbow trout and Australian mussels, all produced exclusively in Australia.

Shrimp of the genus *Panaeus* are produced exclusively in New Caledonia while ark clams of the genus *Anadara* originate almost totally from Fiji.

Table 1.18 The 12 most common aquaculture species in Oceania, 1995-2000

Species	Production (tonnes)						
	1995	1996	1997	1998	1999	2000	% in 2000
1. New Zealand mussel	62 519	65 000	65 500	75 000	71 000	76 000	54.5%
2. Atlantic salmon	6 192	7 647	7 648	7 069	9 195	10 907	7.8%
3. Pacific oyster	6 981	8 395	12 434	16 879	20 580	10 773	7.7%
4. Eucheuma PPS	5 248	9 480	7 376	6 148	10 905	10 020	7.2%
5. Southern bluefin tuna	1 927	2 013	2 089	5 140	6 365	7 803	5.6%
6. Chinook salmon	5 000	6 400	4 350	5 807	5 700	6 140	4.4%
7. Australian oysters	5 180	5 180	5 328	5 328	5 104	5 584	4.0%
8. Giant tiger shrimp	1 643	1 445	1 351	1 326	2 342	2 654	1.9%
9. Rainbow trout	1 747	1 902	2 090	2 115	1 652	1 949	1.4%
10. Australian mussels	830	907	1 122	1 482	1 692	1 771	1.3%
11. Penaeus shrimp nie*	880	936	1 107	1 569	1 906	1 723	1.2%
12. Anadara ark clams nie*	.	.	.	.	1 416	1 416	1.0%
Total 12 species	98 147	109 305	110 395	127 863	137 857	136 740	98.1%
Total for Oceania	99 485	111 177	112 679	130 263	140 300	139 432	100.0%

Source : FAO Fishstat Database Version 2.3. 2002.
*nie: not included elsewhere

The development of aquaculture in Oceania will be largely dependent on the performance of Australia and New Zealand. In Australia, the aquaculture industry enjoys strong government support. In 1999, the Australian government forecast a substantial increase in the value of production for 2010 with sales rising from AUS$600 million to more than AUS$2,500 million, more than a fourfold increase (DAFFA, 2001). The Australian government, in partnership with all players involved, is now developing a national action plan to reach this objective, especially through the legal and regulatory structure, as well as programs and services. There is a consensus on the sector's real development potential. This growth will be achieved through consolidation of existing operations, but also through industry diversification. Species such as abalone, mussels, snapper and crayfish have been determined to offer solid potential.

The New Zealand government states that aquaculture will account for the largest share of growth in the marine sector. In late fall 2001, however, New Zealand decreed a moratorium on the issuance of new aquaculture licences for two years.

This moratorium covers most New Zealand coastal zones and was implemented primarily to enable the government, after consulting with all players directly involved and with the general public, to develop a series of legislative and regulatory reforms to be tabled in Parliament in spring 2003. Briefly, the very essence of these reforms will be the introduction of a zoning system to allow governing aquaculture in suitable areas and prohibit it in unsuitable areas or areas requiring special protection.

For the other Pacific islands, Adams *et al.* (2001) believe that the greatest potential for development lies in the production of aquarium stock, production of live fish for the domestic market and production of inputs for the pharmacological industry. All cases involve high-value products that can be raised in fairly limited space with fairly simple technology.

For more detailed information regarding Australia and New Zealand, see Section 2.1 and Section 2.7 respectively.

SECTION II

THE INTERNATIONAL CONTEXT FOR AQUACULTURE DEVELOPMENT

CASE STUDIES:

AUSTRALIA
CHILE
SPAIN
UNITED STATES
FRANCE
NORWAY
NEW ZEALAND
UNITED KINGDOM (SCOTLAND)
EUROPEAN UNION

2.1 AUSTRALIA

2.1.1 Production, economic impact and industry organization

In 2000, Australia issued some 3,200 aquaculture licences, 60% to land-based operations and 40% to saltwater sites. Seaweed production, however, represented only 4% of the total value of Australian aquaculture production, about $25 million out of a total $644 million.[1] For that same year, aquaculture production represented 29% of all fisheries output, with captures accounting for the other 71%. In theory, the term of a licence varies from state to state, from four years to perpetuity. In practice, however, most licences are issued for periods ranging from five to 21 years (AFFA, 2001).

Table 2.1 shows Australia's production from 1995 to 2000. Production rose from 22,380 tonnes in 1995 to 39,909 tonnes, for an average annual growth rate of 18.5%. The main species farmed are Atlantic salmon, southern bluefin tuna, oysters and giant tiger shrimp.

Table 2.1 Australian aquaculture production, 1995 - 2000

Species	Production (tonnes)					
	1995	1996	1997	1998	1999	2000
Atlantic salmon	6,192	7,647	7,648	7,069	9,195	10,907
Southern bluefin tuna	1,927	2,013	2,089	5,140	6,365	7,803
Pacific oyster	4,049	4,926	5,389	3,852	5,600	7,242
Australian oyster	5,180	5,180	5,328	5,328	5,104	5,584
Giant tiger shrimp	1,613	1,412	1,278	1,278	2,290	2,594
Rainbow trout	1,739	1,894	2,083	2,109	1,646	1,942
Australian mussel	830	907	1,122	1,482	1,692	1,771
Barramundi perch	258	596	487	683	895	934
Bidyanus bidyanus	21	33	115	162	195	320
Cherax destructor	273	161	188	230	245	290
Kuruma shrimp	35	216	115	115	154	205
Freshwater fish nie*	-	-	188	96	50	90
Cherax quadricarinatus	42	56	64	64	78	77
Cherax tenuimanus	21	32	52	55	49	52
Saltwater fish nie*	-	-	95	47	25	45
Oysters nie*	.	35	26	26	27	27
Australian eel	200	201	315	315	119	26
TOTAL	22,380	25,309	26,582	28,051	33,729	39,909

Source : FAO Fishstat Database Version 2.3. 2002.
*nie : not included elsewhere

Most tuna production involves the capture of juveniles on the open sea and growing them out in a controlled environment.

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[1] All financial data are quoted in Canadian dollars unless otherwise indicated.

Fewer than 100 of the largest companies account for 90% of production value, almost exclusively from mariculture. This is because ownership of property on land is easy and completely private in nature, while the public nature of the ocean environment entails a lengthy and costly process for obtaining access to sites that discourages small investors.

The vast majority of salmon production is for the domestic market, since only 15% of the volume is exported. Almost all bluefin tuna is exported to Japan for sashimi. More than 98 percent of production of edible oysters is also exported, while more than 93% of giant tiger shrimp production serves the domestic market.

It should be noted that the production statistics in Table 2.1 do not include oysters farmed for pearls. This production alone represented a value of $164M in 2000 and more than 1,000 jobs. The vast majority of this production is exported (ABARE, 2001).

Production of pearls, salmon, tuna, oysters and giant tiger shrimp accounts for more than 85% of total output.

Australia's aquaculture production is spread throughout the country for most species, with only Atlantic salmon operations concentrated in the state of Tasmania.

In general, the five largest export markets for Australian production are: Japan (1), Hong Kong (2), Taipei (3), the United States (4) and Singapore (5). In 2000, these five absorbed 77% of Australian exports.

In 1998, the aquaculture job market amounted to some 7,290 direct jobs (full time and seasonal) and 22,1000 indirect jobs, for a grand total of 29,390 jobs (Cox *et al.* 2001).

A recent federal government study found that Australian aquaculture shows solid growth potential not only for traditional species but also for diversification (ABARE, 2002). Native species that should receive special attention in the coming years from public authorities involved in research and development as well as by the industry are abalone, mussels, snapper and crayfish.

Australia's aquaculture industry now has more than 50 industry associations and councils to promote its interests. The largest is the National Aquaculture Council, for which the membership represents about 60% of the farm gate value of aquaculture production. Member associations and organizations of this council are:

- New South Wales Association (oysters);
- Australian Tuna Boat Owners' Association;
- Aquaculture Council of Tasmania;
- South Australian Oyster Growers' Association;
- Australian Prawn Farmers Association (Queensland);
- Pet Industry Joint Advisory Council;
- Aquaculture Council of Western Australia.

2.1.2 Governance structures

Australia has a federal parliamentary system and six states, each with its own government (South Australia, Western Australia, New South Wales, Queensland, Tasmania, Victoria) and two territories (Northern Territory and Capital Territory).

Australia's federal government has no specific legal responsibility to manage aquaculture. Federal legislation on industrial economic development, food safety, aquatic animal health, quarantine, trade and the tax system applies to aquaculture to various degrees based on the situation (AFFA, 2001). The federal government's role in aquaculture development includes sustainable development of the industry, funding for academic training programs and research, animal health inspection and quarantine services, coordination of animal health management, coordination of interventions involving product safety, access to markets and trade, international relations, business development and participation in all matters with state and territorial governments, which requires national coordination. The Department of Agriculture, Fisheries and Forestry is the Australian federal government's primary aquaculture agency.

In turn, Austrialia's state and territorial governments have specific legal responsibilities for daily management of their respective aquaculture industries. The states generally are directly involved in the legal and regulatory framework governing Australian aquaculture which primarily involves land-based fish farming or operations using an inshore saltwater site (therefore within state territorial limits, within three miles of the coast) not under federal jurisdiction (between three and 200 miles). This framework varies from state to state. The roles of states and territories includes promoting sustainable development of the sector, management and issuance of required licences and authorizations (access to resources, including broodstock and smolts in the natural environment), funding for research and education, diagnostic services for farmed aquatic organisms, food safety, technical and professional support services, and export and business development (AFFA, 2001).

Coordination of national issues among all these players falls under the authority of the Council of Ministers of Fisheries, Forestry and Aquaculture (CMFFA). The work of this organization is supported by several committees, including the Standing Committee on Fisheries and Aquaculture (SCFA). A subcommittee of the SCFA deals exclusively with national issues involving aquaculture. This subcommittee consists of representatives from the federal government, the states and territories, as well as the Commonwealth Scientific and Industrial Research Organization (CSIRO).

It should be noted that Australia and New Zealand cooperate very closely in the field of aquaculture through two statutory government organizations, the Australian and New Zealand Environment and Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand. These two organizations handle matters of mutual interest such as natural resource conservation and management as well as food safety.

2.1.3 Historical background

In the early 1990s, a task force of the Australia and New Zealand Fisheries and Aquaculture Council (now the CMFFA) began work and the technical studies required to develop a national aquaculture strategy (ANZFAC, 1992a and 1992b). Following this preparatory work, SCFA proposed a National Aquaculture Strategy in 1994. The primary purpose of this strategy was to propose a framework for managing growth of Australia's aquaculture sector, for which enormous growth potential had been identified as early as 1988 by the Australian Science, Technology and Engineering Council. This strategy covered issues such as organization and structure of the industry, environmental management, marketing and development of new products, quarantine and research and development (SCFA, 1994).

In 1997, the SCFA aquaculture subcommittee conducted an assessment of the progress achieved since implementation of the Strategy, three years earlier. It found that growth in aquaculture production in Australia was significant and steady, but that many problems remained, especially involving access to resources, environmental management and market access (SCFA, 1997). The report concluded that unless these issues were resolved, Australia's output could not reach its full potential.

The following year, as federal involvement in aquaculture continued to grow, a national approach had to be developed to manage aquatic animal health. On April 30 1999, the Council of Ministers of Fisheries, Forestry and Aquaculture (CMFFA) officially ratified the National Strategic Plan for aquatic animal health 1998-2003 – AQUAPLAN (AFFA, 1999). Some time earlier, this national plan had received the support of aquaculture industry organizations, as well as fisheries organizations, including those for recreational fisheries, which meant that it expressed a clear consensus.

In 1998, the Australian industry adopted a national code of conduct for aquaculture (AAF, 1998). This code sets out five guiding principles to ensure sustainable development of the sector: compliance with regulations, respect for the rights and safety of other users of the environment, environmental protection, the well-being of the organisms cultivated and the safety of products for human consumption. It should be noted that compliance with the code of conduct is an essential condition for any aquaculture operator or industry association seeking membership in the National Aquaculture Council.

In 1999, the federal government convened all players in the aquaculture sector, as well as representatives of all states and territories, to a new national conference on aquaculture beyond the year 2000. The purpose of the conference was, once again, to identify the issues facing the industry and to propose workable solutions. The two key outcomes from this conference were a consensus on a vision of what Australian aquaculture should be and a formal agreement by all players to develop an action plan to achieve this vision based on the identification of opportunities open to the industry and the removal of obstacles currently hindering sustainable growth and achievement of the industry's full potential.

2.1.4 Recent developments and current issues

National Action Plan

In 2000, the government officially supported this initiative by proposing a new National Aquaculture Development Committee (NADC), consisting mostly of industry representatives, to supervise all of the work required to enhance the industry's prospects for growth. In 2001, NADC tabled a discussion paper on this issue (AFFA, 2001) and following broad-based consultation, proposed its Action Plan in July 2002 (NADC, 2002). The cornerstone of this action plan is set out in the mission statement drafted in 1999 at the national conference (ACIL, 1999), which proposes that:

> *In 2010, a dynamic, sustainable and rapidly growing Australian aquaculture industry will generate annual sales of at least $2.5 billion, as the most competitive in the world.*

Achieving this production target by 2010 would raise the industry's level of direct employment to some 36,000 jobs, thereby creating more than more than 29,000 direct jobs in the sector. Although it may seem optimistic, this target is based on an individual assessment of the potential of traditional species and new species, and on Australia's major comparative advantages:

- the reputation of Australian fisheries products as safe, high quality and originating from a *clean green* environment;
- the proximity of major Asian markets;
- the fact that Australia is free of the main diseases affecting aquatic animals farmed elsewhere around the world;
- the excellent nutritional qualities of native Australian species; and
- the aquaculture and fish harvesting season, which is the reverse of that in major producing countries in the northern hemisphere.

To meet this target, NADC proposes eight initiatives in its action plan:

1. The need for a national aquaculture policy

    - Clear message to the public, the industry and investors about unfailing government support for the sustainable development of Australian aquaculture;
    - Planning for growth through: 1. Legal recognition of aquaculture in waters under federal jurisdiction since growth in production will require the development of offshore technology (aquaculture is not yet legally recognized in the 1991 *Fisheries Management Act*) and 2. Introduction of principles of integrated management into regional marine development plans based on what has already been done in states such as Tasmania, New South Wales, Victoria, and South Australia.

2. Implementation of the action plan must be led by the industry

    - Need to create an umbrella organization to oversee all the others (Australia currently has more than 50 industry associations and councils).

3. Growth of the industry based on sustainable development

    - access to necessary resources and infrastructure;
    - streamlined environmental assessment process under the *Environment Protection and Biodiversity Conservation Act;*
    - integration of aquaculture activities with agriculture;
    - institute Code of Good Practice and conduct third-party audits where possible;
    - promote access to therapeutic products: any chemical product used must first be assessed and approved by the *National Registration Authority for Agriculture and Veterinary Chemicals* which is currently developing a national framework for registering chemical and therapeutic products for aquaculture; the goal is to

establish an effective, low-cost mechanism for approving new products and ensuring that they are used responsibly;

- continue to implement the *National Policy on Movements of Aquatic Organisms (1999)* to control and mitigate any adverse impact;
- since, consumer concerns about food safety of marin products pose the main obstacle to increasing domestic consumption, the entire marine sector should develop integrated production and processing standards;
- aquatic animal health; ensure funding for AQUAPLAN 1998-2003; introduction of an exotic disease through imports of marine or other products is seen as the most serious threat to growth of Australia's aquaculture industry;
- the government must consider the problem of ballast water in ocean carriers.

4. Invest to increase production

   - need to develop an investment strategy to support growth of the industry.; assessment of the tax system and individual taxes and fees to determine whether they pose an obstacle to investment in aquaculture.

5. Promote aquaculture products in Australia and export markets

   - generic promotion (Australia branding)
   - form a marine products promotional unit within the Department of Foreign Affairs and Trade to help the industry negotiate better access to foreign markets with solid growth potential.

6. Tackle the challenges of research and innovation vital to the industry's competitiveness

   - better coordination among all players through industry participation in prioritizing objectives;
   - better alignment of projects with the industry's needs;
   - government and industry incentives and encouragement for all aquaculture sectors to invest, over the next three years, at least 0.25% of the current annual value of products to support research and innovation.

7. Capitalize fully on education, training and the work environment

   - Invest more in education, especially through the training program in the marine products sector.

8. Create an industry for all Australians.

   - Develop a national strategy to increase participation by native communities in aquaculture. As part of this strategy, regions with solid biophysical potential will be identified. For each region, the species to be developed, required production systems and strategies will have to be identified for putting into place elements such as project start-ups, and required training, financing and infrastructure.

Strategy for involving native peoples in aquaculture

Australia's Department of Agriculture, Fisheries and Forestry is currently funding a major study to develop a national strategy for native involvement in aquaculture. This study has two components: the first will propose a national policy and suitable management framework to accelerate involvement by native communities in aquaculture; the second will develop this strategy with the goal of greater economic independence for these communities and of food production based on aquaculture systems. All these initiatives are now being carried out based on broad consultations with native communities, the general public, the aquaculture industry, regional councils, research institutions and governments.

Aquaculture – agriculture integration

It is interesting to note that Australia is planning to develop aquaculture through better integration of aquaculture activities with existing agricultural production systems. This focus is based on the premise that there is a real opportunity to enhance the effective and efficient use of water resources, and thus the economic benefits for farmers and rural Australia, by encouraging integrated aquaculture and agricultural activities. This integration is possible for freshwater species through better utilization of the water resource used to irrigate farm land in many regions, but also for saltwater species through the use of inland saltwater springs.

There is general agreement that the opportunities provided by some species or existing or future agricultural production systems first must be identified. The federal government therefore has funded a five-year R&D plan for integrated aqua-agricultural systems, based in particular on foreign experiments, such as that in Israel, for example (Gooley, 2000).

This plan was tabled in 2000 and has five components:

- an inventory of work already published and of the potential of this technique for the purpose of disseminating information to aquaculture operators and farmers;
- an assessment of the biological parameters and technology applicable to potential species;
- an assessment of the markets for products from such systems and development of technical and economic standards;
- for dissemination purposes, assemble the policies, regulations and environmental management framework that might apply to such systems, and develop a mass budget for each production planned;
- promote access to the necessary training and technical and professional support, specifically through the establishment of demonstration farms.

Implementation of this plan has already begun. A task force of federal, state and territory representatives has been formed to coordinate and promote at the national level development of strategic projects for integrated aqua-agricultural production.

Research and development strategy

In 1998, the state of South Australia adopted a detailed research and development strategy to ensure smooth development of its aquaculture sector. This strategy centres on 10 points:

- production;

- the environment;
- public perception and image of aquaculture;
- the health of cultivated organisms;
- post-harvest activities;
- quality assurance;
- technology transfer and dissemination of information;
- marketing;
- value and economic impact; and
- development of new species.

Although this is an R&D strategy, it is interesting to note that this document calls for specific actions in fields not usually associated directly with research activities, but much more with development activities (SAFRAB. 1998). This integrated, comprehensive approach to development of the sector through research and development activities therefore has the merit of encompassing all aspects of the industry.

Integrated coastal zone management (ICZM)

In several states, such as Tasmania, New South Wales and Victoria, the principles of integrated resource management or integrated management of coastal zones under their jurisdiction have been incorporated into regional development planning. This is now true of South Australia as well, which recently announced the creation of its first marine zone of 14,000 hectares reserved for new aquaculture projects. The purpose in creating this zone is to give developers access to new sites in a clear and predictable legal and political environment to facilitate the new process for granting new sites. Ultimately, this will secure the investments of those who obtain the required licences, while reassuring the public that these developments will be carried out in compliance with sustainable development principles.

As stated earlier, the federal government has not yet implemented an integrated management system for coastal zones under its jurisdiction, especially as part of foreseeable and desirable developments in production through new technology to support offshore aquaculture.

2.1.5 Major programs and services provided by the federal government of Australia

This section details several important programs and services that support Australia's aquaculture sector. It should be noted that this section presents the most relevant programs and services provided by the federal government alone or in partnership with state or territorial governments under multilateral or bilateral agreements. Each state or territory also has its own jurisdiction and thus its own areas of authority, so other programs and services developed by these administrations support the federal or shared programs and services.

Research and development

In 1997, Australia's public spending on R&D in the aquaculture sector totalled some $23.6M or 5.2 % of the value of output for that same year.

There are six main organizations active in R&D at the federal level directly involved in aquaculture through various internal or external programs.

- The *Fisheries Research and Development Corporation (FRDC)*. This national organization is responsible for planning, funding and management of R&D projects in fisheries and aquaculture. FRDC does not actually carry out any projects, but once a year, invites researchers to submit project ideas as part of its five-year R&D plan. FRDC may also propose very specific projects that meet a well-defined need, and call for submissions for their implementation. Finally, FRDC partially funds the activities of *Seafood Services Australia* (see Technical Support for Business section). FRDC has three main programs: sustainable natural resources development, industry development (commercial fisheries, recreational fisheries and aquaculture) and human resources development. In 2001, FRDC had an annual budget of about $16M, with more than 25% allocated directly to activities related to the aquaculture sector. FRDC is funded mostly by the federal government, but also in part by the industry (commercial and sports fisheries, aquaculture) according to the following principles:
    - the federal government provides a base subsidy of 0.5% of the average value of industry landings (AVIL) for the previous three fiscal years (more than $9M in 2001);
    - the industry and its partners in all states and territories participate directly in funding all projects based on the user-pay principle for FRDC services (more than $3M in 2001);
    - the federal government provides an additional contribution equivalent to the industry contribution for the previous year up to a maximum of 0.25% of AVIL (more than $3M in 2001).

  This corporation takes a truly dynamic approach to carrying out its terms of reference and the number of projects conducted in recent years as well as significant participation in these projects by the industry (especially in terms of financial contribution) appears to demonstrate a high level of industry satisfaction with the services it receives.

- The *Australia Research Council (ARC)*. Main funding organization for basic research in science, engineering and new technology.

- The *Commonwealth Scientific and Industrial Research Organisation (CSIRO)*. This is one of Australia's largest research organizations. CSIRO conducts strategic research projects in fields such as agriculture, mining and energy, manufacturing, communications and the environment. This organization is involved in part in the work of the Standing Committee on Fisheries and Aquaculture.

- The *Australian Bureau of Agriculture and Resource Economics (ABARE)*. This bureau is an independent agency specializing in economic research and forecasting for primary sector industries. Fifty-one percent of the budget is provided by the federal government, while the remainder is earned through its own activities (publications, conferences and consulting services).

- The *Bureau of Rural Science (BRS)*. This bureau is actually a branch of the Department of Agriculture, Fisheries and Forestry (DAFF). Its main mission is to provide the government with scientific advice on sustainable development of all economic sectors under DAFF jurisdiction.

- The *Rural Industries Research and Development Corporation (RIRDC)*. This national organization is responsible for planning, funding and management of research and development activities for rural industries. It is interesting to note that this corporation issues a request for proposals once a year to fund projects it has identified as being priorities.

Food safety

In 1998, Australia introduced its program to control shellfish safety in response to the Tasmanian oyster industry's growing need for government inspection and quarantine services. Since then, the program now known as the Australian Shellfish Quality Assurance Program (ASCAP) has been modernized due to a notable increase in the country's aquaculture production and growing pressure from human pollution near many cultivation sites. ASCAP objectives are to control harvesting of contaminated shellfish by identifying and assessing the impact of pollution on cultivation waters, and to prevent any contamination of shellfish after harvest (post-harvest control). Like similar programs in the United States, Canada and Europe, ASCAP is based on a shellfish zone classification system and strict monitoring of water quality.

ASCAP is administered jointly by the federal government and the states or territories. In theory, its application covers growing areas for the products destined for domestic or export markets. However, implementation varies considerably between states. Although most states make no distinction between cultivated products for domestic consumption or export, some jurisdictions still lack adequate monitoring for domestic sales. Some states also encounter difficulties applying the program to products from traditional harvesting activities other than cultivation. For all these reasons, ASCAP is now under review.

Aquatic Animal health

In 1999, Australia introduced its quinquennal program AQUAPLAN for better coordination of a national approach to managing aquatic animal health. This program was jointly developed by the federal government, states and territories with the industry. It sets out common objectives, projects and specific programs forming an integrated system to monitor, prepare for and respond to any epidemic that might break out in wild stocks or farming operations. AQUAPLAN specifically includes eight programs:

- International context: promote and defend Australia's interests in international trade (imports and exports) in aquatic products.
- Quarantine: review all quarantine policies in light of prevailing international policies, using an open, scientific approach to risk management.
- Monitoring, follow-up and reporting: compile all relevant information and enhance monitoring, follow-up and reporting practices related to outbreaks of diseases, to protect Australia's status in relation to aquatic animal health.
- Preparation and response: develop institutions capable of responding adequately to any emergency and develop manuals and operating instruments describing protocols and methods for effective management of any outbreak of disease in Australia (known as AQUAVETPLAN under the supervision of the Quarantine and Inspection Service–AQIS).
- Awareness: raise awareness of all players to aquatic animal health issues and their impact on product safety and quality (link with all other programs, especially the *Australian Shellfish Quality Assurance Program*).
- Research and development: identify research and development priorities for aquatic animal health and promote projects in this area by the industry and governments.
- Legislation, policies and jurisdiction: facilitate implementation of AQUAPLAN through adequate mechanisms in the various governments and foster implementation of the National Policy on Movement of Aquatic Organisms.

- Resources and funding: develop a system shared by governments and the industry to cover costs related to emergency (special funding), and assess costs and funding for projects required to maintain high standards for managing aquatic animal health in Australia (funding of basic activities).

AQUAPLAN has about $6M in federal government funding for the first five years (1998-2003). It should be noted that FRDC is also involved in design and funding of programs, but at a much more modest level ($25K in 2001).

To manage aquatic animal health more effectively, Australia is considering the establishment of zones based on their health status. Some regions of the country might be declared free of a given disease and thereby obtain special authorizations for marketing products. For example, if marketing of products is banned following outbreak of a disease in a given zone, marketing of products from an adjacent zone might be approved provided that it had been declared free of this disease. With this in mind, guidelines were first developed to define the conditions for establishing such zones (AFFA, 2000).

Inspection services

Australian Quarantine and Inspection Services (AQIS) is responsible for protecting Australian territory from any intrusion by exotic insects or diseases. The government has taken back responsibility for delivering quarantine and inspection services in the states of New South Wales, Victoria, Queensland, South Australia and the Capital Territory. AQIS, an entity in the portfolio of the federal Department of Agriculture, Fisheries and Forestry (DAFF), provides inspection services and issues authorization certificates for export and import of marine products, including aquaculture products. AQIS recovers 100% of its operating costs based on the user-pay principle.

In theory, all marine products for export are inspected by AQIS through random sampling to ensure that products meet standards, that the product description and labelling comply with the regulations in force, and that the requirements of Australian authorities for exports as well as those of importing countries are met. When analytical tests are necessary to demonstrate compliance with standards, these are conducted by government analytical laboratories (Australian Government Analytical Laboratories). Here again, 100% of costs are charged back to users.

A group of experts with the federal Department of Agriculture, Fisheries and Forestry (Biosecurity Australia) is responsible for assessing the risks arising from food imports and instituting the necessary measures. This group is also responsible for technical negotiations with foreign counterparts to facilitate Australian exports.

DAFF also administers a monitoring program for residues present in food (Australian National Residue Survey) in compliance with the standards prescribed by the Australia and New Zealand Food Authority.

In turn, the National Registration Authority for Agricultural and Veterinary Chemicals (NRAAVC) is responsible for assessing and registering all chemical or veterinary products used in part in aquaculture. When use of a given product is authorized, daily monitoring is the responsibility of state and territorial governments. The use of any substance derived from or containing genetically modified biological materials must obtain prior approval of the Advisory Committee on Genetic Manipulation before seeking NRAAVC authorization. Finally, any new anti-bacterial agent must be approved by the Department of Health.

Technical support for business

Recently, the Australian marine products industry created SeaFood Services Australia. This public corporation jointly funded by FRDC, the Food Technology Centre of the Department of Primary Industries in Queensland, and the Association of Marine Product Industries in the same state, provides a broad range of services to all partners in the marine products sector (including capture, cultivation, processing, shipping, wholesale and retail, export and import activities).

First and foremost, SeaFood Services Australia provides information and consulting services to its various clients on subjects such as technology, food safety and regulatory compliance, quality management systems, and the concept of value added, through development of new products or processes.

But to assist in carrying out its mission, SeaFood Services Australia has also developed a financial tool: the Seafood Industry Development Fund with the financial assistance of FRDC. This program provides financial support to applicant companies deemed eligible for projects:

- to overcome constraints and capitalize on business opportunities promoting development of the sector;
- favouring R&D projects integrated into the entire industrial chain (production, processing, marketing);
- enhancing the sector's performance through the adoption of best practices and best standards; and
- generating the best return on investment in R&D.

General assistance for industry development, investment and exports

This type of assistance provided to all industries is managed primarily by three government agencies: AusIndustry, Invest Australia and Austrade. Here is a summary of the most relevant programs.

AusIndustry

- a program supporting cooperative research between universities, government research centres and users of findings in the industry or public services.
- a program to disseminate technology with two components: Technology Alliance to improve Australian access to technology developed elsewhere in the world; and Technology Transfer to help businesses acquire new technology and enhance the industry's competitiveness
- innovation Investment Fund. Venture capital accessible to high technology start-up companies to help them market the results of their work. The public:private investment ratio is 2:1.
- Emerging Technology Marketing Program. Technical and professional support to help market innovative products, processes or services.
- Tradex. Program for export companies exempting them from customs duties and taxes on imported products that will be re-exported or serve as inputs for the manufature of products for export.

Invest Australia

- Financial assistance for pre-feasibility or feasibility studies for major investment projects.
- Regional Antennas Program. Technical, professional and financial assistance to foreign companies seeking to start manufacturing operations or open a regional office in Australia.

Austrade (Australian Trade Commission)

- Professional support for export companies to research information they require, select and develop new export markets, and expansion of their export markets.
- Financial assistance program for marketing in export markets. Financial assistance for representation abroad, missions, advertising and promotional activities, participation in trade fairs and hiring of consultants. This program grants about $130M a year to thousands of companies, primarily SMEs.

Supermarket to Asia Strategy

- Australian government strategy promoting better access to the Asian market for fresh and processed food products. A key component of this strategy focuses on pooling efforts and better cooperation by all Australian palyers in a given sector, to create the critical mass, reliability, uniformity and quality necessary to meet the requirements of new markets, for example.

Assistance to primary sector producers

In 1997, the Australian government launched its national strategy for advancement of the agricultural sector, *Agriculture – Advancing Australia* (AAA), in response to major changes affecting this sector, especially the level of professional skills required to adapt to globalization of trade and a need to become more competitive. This strategy covering the aquaculture sector is supported by many programs, with the most important being:

- AAA- FarmBis. Program covering costs related to all eligible training activities for human resources involved in business management, especially skills development, financial planning, quality control programs and benchmarking. This program is jointly funded by the federal government and the states or territories.
- AAA – FarmBis Australia. Program similar to the one above but focusing on issues involving an entire industry rather than the challenges faced by a company. The target clientele therefore consists of national industry associations. This program is funded solely by the federal government.
- AAA – Farm innovation program. Financial assistance covering up to 50% of the cost of a project for the adoption of innovative practices, processes and products. Under the auspices of DAFF.
- AAA – Growth through exports. This initiative covers the signing of bilateral agreements between the Australian government and another country to facilitate the export of specified products.

- AAA – Stabilization account. Program providing the option of depositing financial surpluses in a secured account one year before taxation. These amounts can then be recovered in more troubled years, at a lower tax rate (equivalent to Canada's income stabilization account). Individuals only are eligible, not companies.
- New industry development program. Government strategy to reduce obstacles and barriers to growth for new industries and their products with solid growth potential.
- Assistance in special circumstances. Financial aid for agricultural operations coping with special, temporary problems. Financial aid in the form of reduced interest rates and payments for essential public services (health care, education, etc.).

Tax incentives

- Tax deductions for R&D expenditures: 125% of deductions on the first expenditures bracket, plus a premium up to a maximum of 175% of deductions for excess expenditures (administered by AusIndustry).
- Discount on diesel fuel for off-road and highway operations.
- Partnership with primary sector industries. This initiative targets better cooperation between the Australian Tax Bureau, certain departments, including DAFF, and certain industry associations, including the Australian Seafood Industry Council, to clarify application of tax laws regarding the tax on products and services and tax reform.

2.2 CHILE

2.2.1 Production, economic impact and industry organization

Chile is the main producing country in South America, with more than 425,000 tonnes of products in 2000 (Table 2.2). This country's aquaculture output posted average annual growth of 15.6% from 1995 to 2000.

This production is heavily dominated by Atlantic salmon, which accounted for 39% of total output in 2000. In volume terms, Atlantic salmon increased from 54,250 tonnes in 1995 to almost 167,000 tonnes in 2000, an increase to three times the initial production. The three main species in Chile's production are all salmonids, since the second is coho salmon (22%), followed by rainbow trout (19%). The significant growth in the last species is not due to massive development of land-based sites, but rather to the use of sea cages. The total farm gate value of Chile's aquaculture production was $1.9 billion in 2000.

Table 2.2 ***Chilean aquaculture production, 1995 - 2000.***

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Atlantic salmon	54,250	77,327	96,675	107,066	103,242	166,897
Coho salmon	44,037	66,988	73,408	76,954	76,324	93,419
Rainbow trout	42,719	54,429	77,110	75,108	50,414	79,566
Gracilaria seaweeds	49,183	105,212	102,767	68,386	31,278	33,471
Chilean mussel	5,595	6,064	8,635	11,911	16,203	23,477
Fan scallop	8,264	9,779	11,482	16,474	20,668	19,018
Pacific oyster	1,313	1,776	3,203	4,076	5,441	5,641
Chinook salmon	371	341	738	108	208	2,524
Cholga mussel	106	199	188	320	566	295
Flatfish nie*	38	168	278	426	334	260
Choro mussel	186	298	261	353	477	224
Chilean flat oyster	204	526	328	247	291	200
Abalone nie*	.	8	1	1	48	66
TOTAL	206,266	323,115	375,113	361,430	305,494	425,058

Source : FAO Fishstat Database Version 2.3. 2002.
*nie : not included elsewhere

Chile still has a large number of suitable sites for development of aquaculture activities based on export markets. However, there are constraints on salmonid production. The most serious are regulatory and administrative: even government representatives admit that the licensing and concession process for public marine areas is lengthy, tedious and costly. There are also economic and market related constraints: major price fluctuations, recurring economic crises affecting major export markets in Asia and charges of dumping against Chilean products are a few examples. Finally, there are technical constraints, since diseases still cause serious losses of inventory.

To remain competitive in international markets, South American operators must also comply with international rules governing trade, health and sustainable development. Hazard Analysis and Critical Control Points (HACCP) and the FAO Code of Conduct for Responsible Fisheries are examples of these new international rules to be observed.

In the late 1990s, Chile drew up a plan to maintain and even surpass its status as the world's second largest producer of salmonids, and the approval of new production sites will contribute to achieving this objective. In that plan, short-term production estimates were approximately 375,000 tonnes for salmonids alone (Hernandez-Rodriguez *et al.*, 2001). These targets had virtually been met by 2000 with close to 340,000 tonnes of Atlantic salmon, coho salmon and rainbow trout.

Chile's aquaculture production is currently responsible for about 5% of revenues from total national exports and for some 40,000 direct jobs. The country has an interest in further developing this industry to produce greater economic benefits, but only within limits of ecologically sustainable growth. The Chilean government is committed to enforcing strict environmental regulations to meet this objective. However, many other activities are carried out near aquaculture areas and undesirable interactions must be prevented to avoid conflicts between the users (Norambuena, 2002. pers. comm.).

In recent years, more than 98% of salmonid production has been exported. The three main export markets are Japan, the United States and Europe. The leading exports to the Japanese market are fresh or frozen whole rainbow trout and various forms of quick-frozen coho salmon (whole or fillets). The American market prefers Atlantic salmon in fillets or whole. The leading export to Europe is whole and quick frozen Atlantic salmon. It should be noted that as exports have grown, Chilean producers have invested massively in processing activities to create value added products and capture a greater share of profits from this increase in value. Processes such as filleting have therefore been developed, as well as new products such as canning (steaks or other cuts) to gain access to more lucrative but especially more price-stable markets. It should be noted that Chile is now striving to develop other markets, specifically in Brazil, Argentina and Mexico, to reduce dependency on its traditional distribution channels. Exports to markets other than Japan, the United States and Europe have risen by 50% a year in recent years (Hernandez-Rodriguez *et al.*, 2001).

Thus, most of the companies involved in salmon production are vertically integrated from the stage of egg production to harvesting and processing. A growing service industry is being developed, mainly related to operational (transport, moving and cleaning of cages), sanitary (diagnostics, and the control and eradication of diseases) and environmental (impact assessment) requirements. Salmon and trout producers are part of a strong and well-funded national association.

However, mussel, scallop, oyster and seaweed producers are less well-organized due the scale of their operations and the technology that is used. The different production sectors have different associations for producers. These associations are partners with government for the purposes of discussion of regulatory changes and are also members of the 13 regional, five zonal and the national fisheries councils.

A study of diversification and growth potential conducted in 2000 (Gotfrit, 2000) estimated that by 2020, salmon and trout production will total more than 800,000 tonnes and continue to dominate Chilean aquaculture (Table 2.3). Scallop production could experience significant growth with 62,000 tonnes produced in 2020. Production of other shellfish, primarily mussels, could reach a volume of 90,000 tonnes. Chilean production of all species combined could reach a total volume in 2020 of 1.2 million tonnes, almost three times the level for 2000, with a value of $6.6 billion. This same study indicates that the following factors will determine Chile's ability to achieve its full potential:

- technological progress and adoption of technology by the industry (including growing techniques in open water or land-based ponds, water recirculation);
- access to significant capital to support the massive investment required;
- the potential revolution in sea ranching, now approved by regulations for managing coastal zones that allow the granting of exclusive rights to operate a marine site to organized, well structured communities of coastal fishers or private companies;
- development of operations cultivating more than one species; and
- diversification of national production into native species rather than focusing on exotic species.

Table 2.3 ***Chilean aquaculture production volumes and values estimated at 2010 and 2020***

	AVERAGE HARVEST (tonnes)	
SPECIES	2010	2020
Salmon and Trout	556,000	838,000
Scallops	41,000	62,000
Shellfish (excluding scallop)	55,000	90,000
Fish (excluding salmonids)	6,000	35,000
Crustaceans	1,000	7,000
Seaweed	95,000	175,000
Total Volume (tons)	**754,000**	**1 207,000**
Production Value	**$ 4,172,000,000**	**$ 6,644,000,000**

Source: Gotfrit 2000.

Furthermore, recent statements by several leaders of large aquaculture organizations in Chile support and even refer to exceeding these forecasts by estimating that Chilean aquaculture exports will generate $4.5 billion by 2010 (Bitran, 2002).

2.2.2 Governance structures

Historically, ocean management in Chile is principally controlled by the Ministry of Defence. Every request for the allocation of coastal space is directly reviewed by its Directemar (Maritime Territory Administration) office. Within the Ministry of Defence, the Subsecretaria de Marina (Undersecretariat for Marine Affairs) is in charge of all marine areas and ocean monitoring. It has the power to grant user rights for submerged lands, as well as use of portions of waterways and concessions for aquaculture and pipelines. It is responsible for military defence, maritime and coastal security, fiscal policies relating to coastal zone management, and for navigable waterways.

However, in 1994 a Policy on Coastal Use was adopted, which is enforced by the Ministry of Defence and other goverment ministries. Some other ministries also allocate sectorial permits for certain activities. It is through government decrees under the Policy on Coastal Use that marine areas may be used for aquaculture. To administer this activity, a Geographic Information System is being implemented, which is meant to support a streamlined system for requesting and granting aquaculture concessions. The Undersecretariat for Marine Affairs is currently working on the aerial photogrametric mapping of Region VII. Use of this system has also improved the decrees related to the designation of *Areas Suitable for Aquaculture* (ASA) in Region IX, and its use is currently allowing for improvements in Region X (Aquanoticias, 2002).

The Undersecretariat of Fisheries, which is under the authority of the Ministry of the Economy, is one of the most important of the "other" ocean authorities. It is the goverment authority responsible for national fisheries and aquaculture policy and also for the determination of Areas Suitable for Aquaculture (ASA). It promulgates regulations and makes financial decisions with regard to the industry and to fisheries and aquaculture activities. An authorization from the Undersecretariat is required for all activities relating to the use of live marine resources, with the National Fishing Service being responsible for enforcement of related regulations.

As described by Bjorndal (2002), a licence consists of an authorization for aquaculture operations together with a licence for breeding activities. A licence covers the entire water column from the surface area to the bottom, inclusively. The licence is granted for an indefinite period, with the licensee having the right to sell or rent it out. A five-year development plan must be submitted together with the application for a concession. At the end of five years, if less than 50 per cent of the activities proposed by the concession holder are not being carried out, the authorities may reduce the size of the concession. A nominal fee is paid for a licence.

In 1989, Chile adopted a comprehensive *Fisheries and Aquaculture Law* which was subsequently amended twice and then consolidated in 1991 (Office of the Comptroller General of Chile, 1991). This law relates to the conservation of commercial and recreational fisheries as well as to aquaculture in the EEZ and continental waters. In addition, it applies to areas bordering the EEZ, which are, or could be, under national jurisdiction in accordance with international laws and treaties.

The government policies dealing with environmental and development issues are coordinated by the Comisión Nacional del Medio Ambiente – CONAMA - (National Commission for the Environment). This institution is regulated by the *Environmental Law*, which was promulgated in 1994. All activities regarding investment and planning that could have adverse effects on the environment must undergo an environmental impact assessment. This may either be in the form of an Environmental Impact Statement (for small projects) or an Environmental Impact Study (for large projects). During the evaluation process, there is a formal system for public participation. CONAMA has the responsibility for coordination, and is the only spokesperson for investors. It is also responsible for approving or denying authorizations of projects, which may require include conditions or amendments. As well, the office is also responsible for the development of national environmental policy.

At present, there is a degree of integration between the fisheries and aquaculture sectors, at least with respect to small-scale fishers, as an significant number of them already have concessions covering small areas for aquaculture projects, mainly for production of mussels and algae. According to staff from the Fisheries Undersecretariat, there is enormous potential for the integration of fisheries and aquaculture because the government has established a system where organizations representing those who fish on a small scale have the exclusive use of benthic resources in a specific area (*Regulation for the Management of Coastal Areas*). A substantial part of these managed areas are in need of restocking programs which would enhance their productivity. And aquaculture could provide the seeding stock for this purpose.

Sixteen species are currently being cultivated in Chile: nine are species that have been introduced (such as salmon, trout, abalone, and turbot) and seven are native (mussels, scallops, seaweed, and Chilean oysters). The Chilean government's goal is to foster the production of at least 25 different species by the end of 2005 (Norambuena, 2002).

Most Chilean companies are owned by domestic investors and the current trend is towards greater concentration of ownership in fewer companies. There is no restriction on foreign ownership.

2.2.3 Recent developments and current issues

New Aquaculture Policy

Chile is currently developing an Aquaculture Policy for the next 20 years. The policy will include significant provisions regarding sustainability, coordination with other (aquatic) activities, land use, Marine Protected Areas, water and sediment quality regulations and other matters. The policy will be discussed initially among representatives of government institutions, to be followed by consultation with the public (Norambuena, 2002). With respect to the future of aquaculture development in Chile, the Undersecretariat for Fisheries has forecast an increase from 435 licences in 2000, to 1,200 in 2010 for the salmon industry alone. This amounts to almost a three-fold increase within a decade (Bjorndal, 2002). This confirms the fact that in Chile, as in many other countries in South America, there are still a large number of good sites available. However, even the staff of the Undersecretiat for Fisheries say that, to achieve this goal, the major challenge currently being faced is bringing about changes to the legislation and regulations so that the success of aquaculture enterprises will be related exclusively to its management without being impeded by administrative contraints (Sandoval, 2002).

In conclusion, the Government of Chile will promote the growth of the aquaculture industry, taking into account considerations relating to coastal communities, small-scale fishermen, the rational and integrated use of coastal areas, and prevention of pollution and of undesirable environmental effects, including threats to marine biodiversity.

New Free Trade Agreement with United States

The current negotiations with the U.S.A. regarding a Free Trade Agreement obviously could have a positive impact on Chilean exports into the American market and, consequently, a negative impact on others exporters. Some Chilean products now face some import tariffs for Atlantic salmon and trout. If these barriers were to disappear, it may be presumed that Chilean producers would gain some additional competitive advantage in this lucrative, but congested market.

2.2.4 Major programs and services provided

Information contained in this section comes from three main sources : firstly, from discussions with staff from the Under-Secretariat for Fisheries; secondly, from the web sites of the organizations described below; and thirdly, from a study prepared for the Office of the Commissioner for Aquaculture Development (Rogers, 2000).

Research and Development

FISHERIES DEVELOPMENT INSTITUTE / INSTITUTO DE FOMENTO PESQUERO (IFOP)

The Fisheries Development Institute (IFOP) is Chile's major state organization dedicated to fisheries and aquaculture research. IFOP's executive office and main research activities are based in Valparaiso, while zonal offices and facilities are spread throughout the country. IFOP's main mandate is to carry out scientific and technological research oriented towards maximum exploitation of fisheries resources and to develop methods, technologies and new systems for upgrading aquaculture and stock enhancement.

In the field of aquaculture, the IFOP's activities are directed toward applied scientific research. It provides technical assistance and services relating to aquaculture, culture of algae, (fish?) stocking, genetics and biotechnology, as well as carrying out environmental impact assessments. Its areas of activity involving salmon include the pathology, feeding and production of coho, Atlantic and sakura salmon eggs and smolts, formulation of diets, and analysis of fish diseases (Rogers, 2000).

IFOP produces mollusc seed for farming and stocking, and is involved in strain selection and genetic improvement for molluscs. IFOP also provides services to seaweed farmers, and assists in the management of artificial seaweed beds.

To do so, IFOP works in close collaboration with Chilean universities and receives funds from different, competitively awarded funding sources that support aquaculture R&D. These include the *Fondef of Conicyt*, the Innovation Development Fund of the Production Development Corporation (CORFO), and the Agriculture Research Fund (FIA) of the Ministry of Agriculture.

FUNDACIÓN CHILE

Fundación Chile is a private corporation whose main objective is to foster technology transfers that will contribute to better use of Chile's natural resources and productive capacity. Fundación Chile has three main departments: the Department of Agribusiness, the Department of Forestry and the Department of Marine Resources. The Department of Marine Resources is very involved in the aquaculture sector. For example, it was responsible for the introduction of cage culture of salmon and later of the development of northern scallops culture, in conjunction with other organizations. It has also developed projects to introduce red abalone and turbot, with the production of both of these having become very important (Rogers, 2000).

Activities carried out by the Department of Marine Resources of Fundación Chile that are aimed at encouraging the development of aquaculture in Chile include:

- through the use of biotechnology, development of a new generation of lower cost and lower risk vaccines;
- development of health and environment services for sector companies;
- development and adaptation of water recycling technology and establishment of an engineering company to foster its use within the industry;
- carrying out research to diversify the range of aquaculture products offered, through farming of southern hake, sea bass, Chilean croaker, catfish and hirame; and
- carrying out technology transfer activities and providing support with regard to health and water recycling issues to help develop turbot and abalone farming.

FUNDACION CHINQUIHUE

Located in Puerto Montt, the main role of this organization is to assist and develop shellfish production on Chiloe Island and in the surrounding areas. It receives funding from Region X Government.

THE SALMON TECHNOLOGY INSTITUTE (*INSTITUTO TECNOLOGICO DEL SALMON, INTESAL*)

Established in 1993 by the Association of Salmon and Trout Producers of Chile and partially funded by National government, this industry organization undertakes research on environmental aspects of and on fish diseases. Moreover, Intesal offers extansion services on fish pathology (diagnostic and treatment) necessary for a good health management practices.

Aquatic Animal Health

The *Regulation on Protection, Control and Eradication Measures for High Risk Aquatic Animal Diseases* (Office of the Comptroller General of Chile, 2001) sets out protection and control measures to be taken to prevent the introduction of high-risk aquatic animal diseases, either in farm species or wild species, to isolate them in case of an occurrence, prevent the spread and ensure the eradication of disease. The provisions of this regulation apply to all activities such as fish farming, transportation, restocking and processing of aquatic animals carried out within Chilean territory. The importation of aquatic animals and research activities are also governed by the provisions of this regulation. But it should be noted that, at present, Chile does not have any mechanism to provide compensation in relation to any eradication order.

Risk Management

Chile does not have any publicly-funded crop insurance program that provides protection to aquaculturists against natural disasters (storms, abnormal tides, biotoxins, biological invasions, predators, pollution, lack of food in the wild for shellfish, etc.). However the central government can determine that an area is a "disaster zone" because of natural catastrophes and provide some compensation.

Food Safety

The Chilean National Fisheries Service (Sernapesca) has developed formal quality control programs for export products. Molluscs farms and processing facilities and fish farms and processing plants that export their production must have Hazard Analysis and Control of Critical Points (HACCP) plans.

On a monthly basis, processing facilities are inspected with a view to controlling the presence of pharmaceutical and contaminant residues in the meat and skin of fish. As well, this includes a formal system for taking samples at marine farms to detect prohibited substances. This initiative is aimed at detecting pharmaceutical products, contaminants and prohibited substances in salmon.

2.3 SPAIN[2]

2.3.1 Production, economic impact and industry organization

Up until the early 1980s Spain's approach to aquaculture was in the form of very traditional, small family businesses. The main species cultured were, and still are, mussels and rainbow trout (Table 2.4). Mussel (*Mytilus galloprovincialis*) culture began as early as 1940, but was not really developed until the mid-sixties and early seventies. Rainbow trout (*Oncorhynchus mykiss*) culture began to be developed during the 1970s.

Table 2.4 Spanish aquaculture production, 1995 - 2000.

Species	Production (tonnes)					
	1995	1996	1997	1998	1999	2000
Mussel	182,250	188,462	188,793	261,062	261,969	247,730
Rainbow trout	22,000	25,000	29,000	30,000	30,000	33,133
Gilthead seabream	2,706	3,818	3,969	4,933	6,117	8,242
Tuna-type fish nie*	15	77	.	1,959	3,346	3,682
European flat oyster	2,170	2,600	2,370	2,545	3,348	3,383
Turbot	2,174	2,189	1,800	1,969	2,849	3,378
European cockle	4,594	2,344	3,770	2,937	3,713	3,104
Japanese clam	.	85	140	1,630	1,826	2,737
Blue clam	.	1,929	3,105	2,408	2,330	1,933
European sea bass	461	693	511	936	1,227	1,837
European cross clam	5,199	751	1,210	1,096	1,052	891
Pacific oyster	900	1,080	980	1,043	681	586
European eel	214	249	335	347	383	411
Atlantic salmon	695	726	851	798	618	226
Queen scallop	.	.	.	207	129	167
Tench	163	160	215	168	161	162
Sturgeons nie*	.	.	.	100	100	140
Small quahog	.	.	.	80	123	119
Mullets nie*	114	125	170	142	88	113
Palemonid shrimp nie*	110	140	225	163	98	110
Oysters nie*	33	40	37	38	41	36
Octopus nie*	.	.	.	32	32	28
Common sole	25	23	18	12	14	13
Atlantic scallop	78	207	206	149	156	9
TOTAL	223,965	231,633	239,136	315,477	321,145	312,171

Source : FAO Fishstat Database Version 2.3. 2002.
*nie : not included elsewhere

Currently, besides the traditional organization of culture, a new, highly industrialized sector is expanding at a rapid pace. In 2000, Spain's production amounted to 300,000 tonnes with a farm gate value of $ 368 million. In terms of volume, Spain is the most important producing country in the European Union. From 1995 to 2000, its annual growth rate was 7 per cent (Table 2.4).

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[2] This section was compiled with the valuable assistance of Liliana Rodriguez-Maynez of the Office of the Commissioner for Aquaculture Development.

More than 24 different species are grown in Spain, but blue mussels are predominant with 79% of total production. From 1995 to 2000, production of this species alone rose by more than 65,000 tonnes. However, Spain is tending to diversify its production. Among the species targeted for production are turbot (*Psetta maxima*), with intensive land-based culture in the north and northeast areas of the country; sea bass (*Dicentrarchus labrax*), and sea bream (*Sparus aurata*), both of which are raised in floating cages in the Mediterranean Sea, the south Atlantic Ocean and waters surrounding the Canary Islands.

APROMAR is the *Asociacion Empresarial de Productores de Cultivos Marinos* (Marine Culture Producers Association), a national organization that includes more than 96% of Spain's marine fish farmers, and representatives of practically all the mollusc and crustacean hatcheries and grow-out facilities. APROMAR is a professional association and its agreements are binding for the whole sector (APROMAR, website). The association is a member of the *Junta Nacional Asesora de Cultivos Marinos* (JACUMAR) which is part of the Ministry of Agriculture, Fish and Food. APROMAR's objective is to protect the interests of the aquaculture sector and to be the spokesperson for the industry with government.

The freshwater aquaculture sector is represented by the *Organizacion de Productores de Acuicultura Continental* (Continental Aquaculture Producers' Organization)

2.3.2 Governance structures

At the national level in Spain, the lead agency for aquaculture is the Ministry of Agriculture, Fisheries and Food. However, Spain is divided into 17 autonomous regions, with each one of them responsible for its own aquaculture regulations.

The first regulations for mussel culture date from 1961. These were updated in 1969, when the need arose to regulate activities in coastal environments. In 1984, the legislation was considered to be unsuitable for the aquaculture activities being carried out, given the major scientific advances that had taken place. The old legislation was considered not only to be obsolete, but to be a barrier to aquaculture development. The national *Law of Marine Farming* (BOE, 1984), was therefore adopted to promote and better regulate the sector's development. This legislation regulates marine aquaculture activities on land, in rivers, rias[3], lagoons, marshes, territorial waters and the exclusive economic zone (EEZ). A second national law that regulates aquaculture is the *Spanish Law Relating to Coasts* (Law 22/1988), which determines, regulates, protects and safeguards the public use of coastal areas and waters under national jurisdiction.

Provisions of the *Law of Marine Farming* include (Sánches-Mata, A. and J. Mora. 2000):

- timeframes for concessions and authorizations of ten years, renewable up to five times;
- deadlines for submission of reports by the authorities;
- authorizations and concessions for experimental farming;
- introductions and transfers of exotic species into Spanish waters, evaluated by the Spanish Oceanographic Institute;

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ria: Lower part of a valley or a system of valleys, that the sea sweeps through.

- ensures, in aquaculture zones, that agricultural and other activities that may alter water quality, meet specific treatment criteria aimed at preventing contamination of aquaculture products.

Depending on the region and the specifics of a project, it takes between one and two years to obtain a permit .

There are specific regulations in Spain relating to water, sediment and biological resource quality, as well as to waste disposal from fish and shellfish farms. The regional environmental agencies (Fisheries, Shellfish and Aquaculture Councils) are responsible for making sure that these regulations are followed.

2.3.3 Recent developments and current issues

White Book on Aquaculture

While Spain is very aware of the potential of aquaculture as a source of protein and economic support, in the last few years, Spain's ranking as a seafood producing country has dropped. To "make up for lost time", and in close collaboration with industry, JACUMAR (*Junta Nacional Asesora de Cultivos Marinos*), an agency of the Ministry of Agriculture, Fish and Food (the lead agency), developed the *White Book on Aquaculture,* whose purpose was to identify and find solutions to bottlenecks for aquaculture development in Spain.

Some of the barriers identified were the lack of financial support but also lack of action by government to establish a favourable regulatory framework whereby aquaculture could reach its full potential. Other barriers identified were the lack of planning for coastal areas, excessive bureaucracy in relation to authorization and concession processes and the almost total lack of involvement of the financial sector. Finally, one of the most significant barriers to development of aquaculture in Spain is public perception of the sector's environmental performance. The *White Book* mentions that aquaculture producers should become more conscious of the environmental factors to be addressed, and more knowledgeable with respect to environmental management and related techniques, as well, it recommends training for the sector's labour force on these matters (JUCUMAR, 2001).

According to the *White Book on Aquaculture*, one of the solutions necessary to move aquaculture forward is the transfer of technology and the carrying out of research beneficial to the industry. In the *White Book* it is mentioned that the lack of motivation to do so, and the lack of public policy co-ordination for R&D hold the sector back immeasurably. In the *White Book* it is concluded that researchers do not know the industry's problems and priorities, which, in the end, translate into research that is of little or no help for advancement of the sector (MAPA, 2002b). As a result, the Spanish government decided to created the *National Aquaculture Observatory (NAO)*.

The NAO will help to establish a strong link between the scientific and technical community and the business world in Spain. Its initial step will be to create databases to identify and describe the potential for aquaculture in Spain at the national level, both in the areas of research and business. The project's budget for 2002-2005 is $1.3 million of which $717,000 will be provided by the Ministry of Agriculture, Fisheries and Food (BOE, 2002a).

Environment Sustainability

In January 2002, the Ministry of Agriculture, Fisheries and Food funded the study: *The Aquaculture Sector: Analysis and Evaluation of the Status, Possibilities and Constraints Relating to the Quality of the Environment, and Certification of its Management* (MAPA, 2002a). Some conclusions of the study are:

- Establishing control quality and/or environment management certification has been slow in the aquaculture industry both at the national and international level;
- Currently, none of the aquaculture businesses in Spain has environmental quality and/or management certification, although some are in the process of obtaining certification (mainly those companies involved with fish and seafood exports);
- The main benefits perceived to result from environmental certification are access to grants and other financial resources, increased competitiveness, access to external markets, and a better brand image ;
- The main constraints to environmental certification are the high material and human resources costs, technical difficulties, lack of training, and lack of knowledge of such process by the consumer and client;
- The aquaculture industry sees environmental certification as a tool to strengthen its position in external markets and compete against countries with low labour costs.

The study recommendations include:

- development of an information guide on environmental quality and/or management specifically for the aquaculture sector;
- moving forward on to the implementation of environmental quality/management systems through information- sharing and financial support for the sector;
- raising awareness among consumers about the value of environmental quality and/or management certification.

It is unlikely that legislation will be drafted relating to environmental certification for the aquaculture industry at this time. However, the fact that the national government is already looking at the current status, opportunities and barriers to this certification may be interpreted as an indication on policy trend for the future.

2.3.4 Major programs and services provided

The programs described below are the principal ones provided by the national and regional agencies for aquaculture development projects in Spain. These are apart from the grants and support available through the European Commission's *Financial Instrument for Fisheries Guidance* that is discussed in Section 2.9.4.

Research and Development

The Profarma II Program supports scientific research, technological development and innovation (BOE, 2002c) in the pharmaceutical and veterinary industries, with multinational and national enterprises eligible for the program. For the period 2001-2003, $2 billion was awarded for projects that address issues ranging from the viability of potential farm species, use of genetically modified fish as biofactories, and sanitary control for sole culture, to development of a system to guarantee the quality of fresh products used for food.

Food Safety

Spain follows the EU regulations regarding food quality standards and the licensing process for therapeutants and pesticides, with a zero-detection limit for levels of therapeutants and pesticides permitted in aquaculture products at the time of harvest.

Aquatic Animal Health

Spain applies the EU Fish Health Regime, which was established to limit the spread, in Europe, of the most serious aquatic animal diseases (see Section 2.9.4 for a comprehensive description of the regime). It should be mentioned that the EU Fish Health Regime does not provide any compensation mechanism in relation to any eradication order.

Processing and Marketing

The *Technical and Management Assistance in the Agriculture, Fisheries, Aquaculture and Food Sectors Program* provides grants for processing and marketing of products. (BOE, 2002b). The funds available for the program in 2002 were $ 1,25 million. Grants provided may amount to as much as 50% of the project costs, but may not to exceed $91, 000, with funds to be used for:

- promotion of quality and innovation in the food sector;
- increasing productivity and improving food safety conditions;
- environmental protection purposes;
- increasing access by small and medium enterprises to new practices for business and management, in particular information technology and communications;
- increasing current and potential market knowledge, and promoting the establishment of businesses at the international level;
- promoting, through the different associations, environmental audits, quality certification, environmental management, work safety and other business management systems; and
- implementing practices to spot production and organizational structural deficiencies, and to find possible solutions.

Risk Management

In Spain, gilthead bream, sea bass, turbot, mussel or marine trout producers can have access to specific experimental insurance programs. These programs cover the following risks: marine predators, diseases, temperature variations, adverse climatic conditions (strong winds and rains), accidents (breakup of tanks caused by vessels and the elements), changes in salinity, black tides and chemical and biological pollution. While the basic plan does not include coverage for all of these risks, a producer may obtain better coverage by paying an extra charge.

These insurance plans are offered by the Spanish Insurance Group for Multiperil Crop Insurance (Agroseguro, S.A.). The aim of AgroSeguro S.A. , a public company founded in 1980, is to manage multiperil crop insurance on behalf of participating insurance companies. To do so, Agroseguro S.A. receives subsidies from the Spanish Government and the Autonomous Communities (local governments). These subsidies cover part of the premium cost for the producers and part of any Agroseguro S.A. annual lost if indemnities exceed total earned premiums.

2.4 UNITED STATES

2.4.1 Production, economic impact and industry organization

American aquaculture production posted low annual growth of about 0.7% from 1995 to 2000, from slightly more than 413,000 tonnes to 428,000 tonnes (Table 2.5). At least 21 species are grown in the United States. Production is largely dominated, however, by channel catfish, which accounts for almost 63% of national production, followed by the Pacific oyster, rainbow trout, quahog, Atlantic salmon and American oyster. In 2000, these six species totalled 91% of production volume.

The value of American aquaculture production was estimated at close to $1.3 billion in 2000. It is estimated that for each dollar of farm gate value, approximately $3.70 is created in increased value throughout this sector's economic cycle. In 1999, the last year for which data are available, the total economic impact of American aquaculture was about $3.7 billion.

Table 2.5 Aquaculture production in the United States of America, 1995 - 2000.

Species	Production (tonnes)					
	1995	1996	1997	1998	1999	2000
Channel catfish	202,706	214,154	238,115	255,990	270,629	269,257
Pacific oyster	34,798	28,815	24,796	31,715	33,259	38,418
Rainbow trout	25,240	24,355	25,719	24,995	27,344	26,837
Quahog	10,942	5,540	17,992	19,943	26,517	23,985
Atlantic salmon	14,075	13,906	18,005	14,507	17,739	22,395
American oyster	73,991	57,005	63,166	53,097	54,037	10,472
Tilapia	6,838	7,242	7,648	8,251	8,051	8,051
Crayfish	26,375	21,130	22,332	17,212	19,455	7,713
Golden Shiner	9,883	9,457	9,040	7,434	7,434	6,330
American sea bass, hybrid	3,772	3,561	3,810	4,257	4,415	5,052
Japanese clam	2,374	1,803	2,363	1,896	3,997	2,381
Common mussel	930	2,237	1,354	1,196	1,244	2,248
Whiteleg shrimp	1,000	1,300	1,200	2,000	2,098	2,163
Cyprinids nie*	-	-	1,542	2,005	2,005	2,005
Blue crab	-	-	115	212	129	488
Oysters, other species	-	-	-	-	-	152
Flat oysters	165	59	147	271	115	108
Common clam	141	111	104	91	.	81
Arctic char	-	-	-	-	-	65
Yellow cockle	11	11	8	10	.	24
Striped flat oyster	126	40	39	20	21	20
TOTAL	413,411	393,331	438,331	445,123	478,679	428,262

Source : FAO Fishstat Database Version 2.3. 2002.
*nie : not included elsewhere

At the national level, the National Aquaculture Association (NAA) is endeavouring to act as an umbrella group for all the regional, state or species-based associations. NAA's mission is to provide a unified national voice for aquaculture that ensures its sustainability, protects its profitability, and encourages its development in an environmentally responsible manner. Other U.S. aquaculture associations include the:

- American Tilapia Association
- Catfish Farmers of America
- Striped Bass Growers Association
- US Shrimp Farming Association
- US Trout Farmers Association
- and many other state and regional associations.

2.4.2 Governance structures

Under the *National Aquaculture Act of 1980* and the *National Aquaculture Improvement Act of 1985*, the federal government created the Joint Subcommittee on Aquaculture (JSA) to serve as a federal interagency coordinating group to increase the overall effectiveness and productivity of federal aquaculture research, technology transfer, and assistance programs.

At that time, the U.S. Congress declared that aquaculture had the potential for reducing the United States trade deficit in fisheries products, for augmenting existing commercial and recreational fisheries, and for producing other renewable resources, thereby assisting the United States in meeting its future food needs. It was, therefore, in the national interest, and it was the national policy, to encourage the development of aquaculture in the United States.

As stipulated in its terms of reference, the JSA is a statutory committee that operates under the aegis of the National Science and Technology Council (NSTC) of the Office of Science and Technology Policy in the Office of the Science Advisor to the President. Although it once reported to the NSTC's Science Committee, the JSA now reports to the NSTC's Committee on Health, Safety, and Food, which is one of five research and development (R&D) committees established by NSTC to prepare coordinated R&D strategies and budget recommendations for achieving national goals.

The JSA membership consists of representatives from the following federal agencies:

- Department of Agriculture (USDA), which is the lead aquaculture agency at the federal level and, accordingly, chairs the JSA
- Department of Commerce (DOC)
- Department of the Interior (USDI)
- Department of Energy (DOE)
- Department of Health and Human Services (DHHS)
- Environmental Protection Agency (EPA)
- Department of Defense (DOD)
- Small Business Administration (SBA)
- Agency for International Development (USAID)
- Tennessee Valley Authority (TVA)
- National Science Foundation (NSF)
- Farm Credit Administration (FCA).
- and any other federal agencies as may be appropriate.

One of the first mandated activities of the JSA was to prepare and publish, in 1983, a *National Aquaculture Development Plan*. In 1996, JSA members agreed to update the plan. The new version was launched several years ago, in a form that is more appropriate to its new status as a subcommittee of NSTC's Health, Safety, and Food Committee. It is now referrred to as an Aquaculture Research and Development Strategic Plan.

This R&D Strategic Plan states that there is a growing consensus within the U.S. that a dramatic increase in aquaculture production is needed to supply future seafood needs. More than 60 per cent of the U.S. demand for seafood is met by imports, resulting in a fisheries trade deficit of several billion dollars annually. Research and development in support of sustainable aquaculture production will improve the ability of the U.S. to supply American consumers and the global marketplace with high quality, safe, wholesome, and affordable U.S. fish and shellfish produced domestically.

The plan sets out the principal areas of research and development that should be emphasized to achieve these goals, and outlines an implementation program to address the following needs:

- increase and transfer scientific knowledge to make the U.S. aquaculture industry competitive in the global marketplace through:
    - increased efficiency and profitability of aquaculture production systems;
    - improved aquaculture production systems;
    - assured quality and safety of aquaculture products;
    - improved marketing of aquaculture products; and
    - improved technology transfer, information dissemination, and access to global information and technology in aquaculture;
- through increased aquaculture production, reduce the fisheries trade deficit and significantly increase exports of aquaculture products;
- ensure that aquaculture development contributes to job creation and growth of the U.S. economy;
- ensure that the industry's long-term development is sustainable and compatible with responsible environmental stewardship;
- provide American consumers with domestically produced, high quality, safe, competitively-priced, and wholesome aquaculture products;
- develop information for and educate seafood consumers and retailers about the nutritional composition, characteristics, proper handling, presentation, and preparation of seafood species and varieties;
- establish and maintain world leadership in fundamental science in support of U.S. aquaculture development;
- encourage the establishment of partnerships in support of aquaculture within federal agencies, among federal and state agencies, and with the private sector;
- encourage aquaculture's contribution to the enhancement, protection, and maintenance of public and private aquatic resources;
- evaluate the potential for development of alternative aquaculture species, production systems, and markets; and
- evaluate options for improving the regulatory framework for aquaculture in support of U.S. aquaculture development in both the commercial and public sectors.

2.4.3 Recent developments and current issues

Department of Commerce Aquaculture Policy

In 1999, the U.S. Department of Commerce launched its own aquaculture policy based on the following vision statement:

> *The DOC and its agencies, working in partnership with USDA, DOI, other Federal agencies, state, local, and tribal governments, environmental organizations, industry, academia, and other stakeholders at the national and regional levels will create a business climate and technological base for industry to develop environmentally sound aquaculture* (DOC, 1999).

One of the interesting characteristics of the policy is the fact that it includes very specific economic and technological objectives to be attained by the year 2025. These are to :

- increase the value of domestic aquaculture production from $1.3 billion in 1999 to $7.4 billion, which will help offset the $9 billion annual U.S. trade deficit in seafood;
- increase the number of jobs in aquaculture from the 1999 estimate of 180,000 to 600,000;
- fine tune aquaculture technologies and methods both to improve production and safeguard the environment, emphasizing, where possible, those technologies that employ pollution prevention rather than pollution control techniques;
- double the value of non-food products and services produced by aquaculture in order to increase industry diversification; and
- increase exports of U.S. aquaculture goods and services from the 1999 value of $750 million annually to $3.75 billion.

This policy also includes a specific objective regarding sea ranching. It stipulates that the U.S. should enhance depleted wild fish stocks through aquaculture, thereby increasing the value of both commercial and recreational landings and improving the state of U.S. aquatic resources.

Ocean Policy

The U.S. Commission on Ocean Policy (USCOP), which was created under the *Ocean Act* of 2000, was authorized by the U.S. Congress and appointed by the President. This Commission is required to "...establish findings and make recommendations for reducing duplication, improving efficiency, enhancing cooperation and modifying the structure of Federal agencies involved in the world's oceans." (USCOP, 2002). The Commission's activities will have a impact on coastal and offshore aquaculture development as its mandate includes reviewing and making recommendations on supply, demand and allocation of marine resources. The Commission's final report should be completed in 2003.

New Initiative in Marine Aquaculture

As mentioned previously, the annual growth rate of the aquaculture sector in the United States has been only 0.7 % over the last few years, with most of it being in freshwater culture. The National Oceanic and Atmospheric Administration (NOAA) and other agencies have been working during the last few years to develop a policy framework for near and offshore marine aquaculture development (Cicin-Sain, 2001). As agreed by many experts, if the U.S. were to expand its marine production, streamlining of the access process in the Exclusive Economic Zone (EEZ) of three to 200 miles would be required as it is acknowledged that one of the principal impediments to realizing the potential for aquaculture in the U.S. is access to ocean space (Woods Hole Oceanographic Institute (WHOI), 2001). In September 2002, NOAA's National Marine Fisheries Service (NMFS) presented a rationale for a *New Initiative in Marine Aquaculture* to help develop the enormous potential of the American aquaculture industry in saltwater. The aim of this proposal is to obtain better support from Congress for the NMFS to implement this initiative (NMFS, 2002). In summary, this new NMFS initiative would :

- identify the focal point within the federal government for research, management, and development of marine aquaculture i.e. establish the NMFS as the lead agency in marine aquaculture;
- initiate the Congressional processes to enact appropriate legal and administrative frameworks for marine aquaculture;
- initiate the Congressional processes to appropriate sufficient funding;
- use the necessary resources in the most sustainable and environmentally compatible way, particularly in the Exclusive Economic Zone (EEZ);
- preserve and possibly improve coastal and marine habitats and ecosystems; and
- explore the potential for using successful species-specific culture techniques as a management strategy option for recovery of depleted natural fisheries stock, species recovery, and habitat conservation.

Specific short-term and long-term recommendations are part of the initiative. One of the most interesting of these is a proposal to streamline and simplify the federal process for granting permits in the EEZ, and create pre-permitted Aquaculture Development Zones (ADZs). More precisely, the role of NMFS in overcoming the constraints to marine aquaculture development fall into two areas :

- improving the business environment: by creating the right legal framework and the right administrative framework for marine aquaculture; by increasing available capital for development (under NMFS fishing industry loan assistance programs); by unifying the national seafood business; by establishing a level playing field for trade (subsidize imports but also eliminating interstate trade barriers); and by increasing management and research outreach;
- improving the protection of the natural environment.

One of the most interesting financial tools proposed to help direct more capital towards marine aquaculture in the proposal are the amendments to the NMFS Capital Construction Fund (CCF).

The CCF is a program that provides a tax incentive to encourage the accumulation of equity funds for fishing vessel investment. This reduces the percentage of future capital cost that vessel owners must borrow. The principle is simple : a fisherman reserves a portion of his annual taxable income in a tax-exempt account (deferred taxes). After up to 25 years, the fisherman can withdraw the money to construct, rebuild or acquire a vessel. Only fishermen are eligible and the funds set aside may only be expended for the purposes mentioned above.

The NMFS has therefore requested that the U.S. Congress amend the CCF's statutory authority by extending it to include aquaculture. This would enable:

- CCF participants to reschedule the expenditure of their accumulated CCF equities reserved for fishing vessels (and future deposits of fishing vessel income, as well) and enable these to be used for aquaculture-related expenditures;
- aquaculturists to begin deferring taxes on taxable income from aquaculture operations and thus accumulate additional equity reserves from within the aquaculture industry.

Farm Security and Rural Investment Act of 2002 (Farm Bill)

The new Farm Bill, adopted in June 2002, requires the USDA to submit a report to Congress in 2002 on efforts to expand the promotion, marketing and purchase of canned salmon harvested and processed in the United States under food and nutrition programs administered by USDA. This provision could have an impact on import levels of these products.

More importantly, following a two-year voluntary program, the Farm Bill requires mandatory country of origin labelling for fish. Any suppliers of commodities that are covered by this bill, such as fish products, must provide information to the U.S. retailer indicating the products' country of origin. Guidelines for the voluntary program were issued in September 2002, and regulations for the mandatory program must be promulgated not later than September 30, 2004.

New Effluent Guidelines for Aquaculture Facilities

In 1999, the Joint Subcommittee on Aquaculture (JSA) created an Aquaculture Effluents Task Force to assist the Environmental Protection Agency (EPA) in conducting a preliminary study on aquaculture effluents.

The *Effluent Guidelines for Aquaculture Facilities* were officially published in June, 2002, with comments requested from the public before the end of the year (EPA, 2002). The proposed regulation introduces new technology-based effluent limitations, guidelines and standards for wastewater discharges associated with the operation of new and existing concentrated aquatic animal production facilities (CAAP). CAAP includes fish hatcheries, finfish farms, shellfish farms, and some aquaria and botanical gardens. Treatment techniques that are foreseen would address issues such as feed management to minimize excess food in the water, health management to reduce disease and the use of drugs, and drug and chemical management plans that include conditions for storage.

The EPA estimates that compliance with the proposed regulation would reduce the discharge of total suspended solids by at least 4.1 million pounds per year and would cost industry an estimated total of $2.25 million per year.

Production Insurance

A study carried out by the USDA stipulated that establishing rates for production insurance in the aquaculture sector would be difficult, mainly because of a lack of a long track record relating to production for many farmed species, difficulties in estimating the inventories for most operations and the fact that there are no widely referred to market quotes to establish an accepted market price for many aquaculture species (Harvey, 1998). Nevertheless, the Federal Crop Insurance Corporation (FCIC) under the umbrella of the USDA's Risk Management Agency (RMA) decided in 1999 to start the first pilot program in aquaculture.

The Hard Shell Pilot Program is available in selected counties in Florida, Massachusetts, South Carolina, and Virginia. The program design aims to document the diverse cultivation technics in different climates that would become the basis for a nation-wide program. Clams were selected to be the first aquatic crop to be tested, in part because of their resistance to disease and because the crop can be secured within a given area. The program provides insurance protection based on the inventory value of the clams. Losses covered include those resulting from oxygen depletion, disease, freezing, hurricane, salinity variations, tidal wave, storm surge or windstorm.

As stated in its *New Program Development and Delivery Priorities for 2001-2005 Crop Year Implementation*, the RMA is planning to develop other pilot programs in 2004 for species other than clams and other shellfish and finfish. To do so, the RMA and Mississippi State University formed a partnership in 2001 to conduct a large-scale study known as the National Risk Management Feasibility Program for Aquaculture. The first four aquaculture species to be investigated are those with the greatest economic value: catfish, salmon, baitfish, and trout.

2.4.4 Major programs and services provided

At least 30 federal aquaculture-related programs are carried out by at least 12 federal departments or agencies, with the most important ones mentioned below. The principal source of information for this section is the web sites of the organizations described.

Research & Development, Technology Transfer, Education and Training

USDA

Aquaculture Program. The mission of the Aquaculture Program provided by the USDA's Agriculture Research Service is to conduct relevant, high quality, basic and applied aquaculture research and carry out technology transfer to create jobs and economic activity that will improve the international competitiveness and sustainability of United States aquaculture, and reduce dependence on imported seafood and threatened ocean fisheries.

The research components of the program include:

- Genetic Improvement
- Integrated Aquatic Animal Health Management
- Reproduction and Early Development
- Growth, Development, and Nutrition
- Aquaculture Production Systems
- Sustainability and Environmental Compatibility of Aquaculture
- Quality, Safety and Variety of Aquaculture Products for Consumers
- Information and Technology Transfer

Co-operative State Research, Education, and Extension Service (CSREES). The CSREES is the agency within the USDA that administers federal funds for extramural research, extension services, and education.

CSREES programs:

- help provide access to science-based knowledge;
- strengthen the capabilities of teaching and other institutions in research, extension, and higher education;
- increase access to and use of improved communication and network systems; and
- promote informed decision-making by producers, families, communities, and other stakeholders.

In fiscal year 2000, total federal extramural funding for aquaculture research programs administered by CSREES was $37 million. Figure 2.1 presents the CSREES expenditures by species groups and Figure 2.2 presents these by research areas.

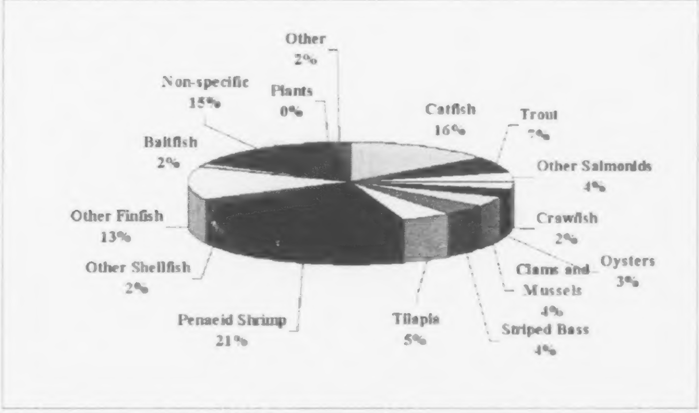

Figure 2.1 **CSREES Aquaculture Expenditures by Species for Fiscal Year 2000 (source CSREES, 2001).**

Under CSREES, five Regional Aquaculture Centers (RACs) have been established since 1985. The RACs encourage an integrated approach for joint research and extension education programs in aquaculture with regional or national coverage. Center programs complement and strengthen existing aquaculture research and extension education programs supported by the U.S. Department of Agriculture, the National Sea Grant College Program, and other public institutions.

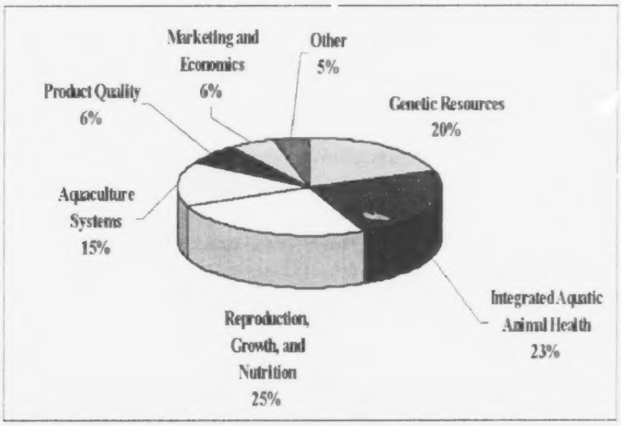

Figure 2.2 CSREES Aquaculture Expenditures by Research Areas for Fiscal Year 2000 (source CSREES, 2001)

Projects that are developed and funded by the RAC are based on industry needs and are designed to benefit directly commercial aquaculture development in all states and territories. Center programs ensure effective coordination and a region-wide collegial approach to project planning and implementation through collaboration by groups involved in research and extension, government and industry. Inter-agency cooperation and joint funding of priority projects are strongly encouraged. The Board of Directors (BOD), the policy-making body for the RACs, incorporates recommendations from an Industry Advisory Council (IAC) and a Technical Committee (TC) to determine funding levels for new and continuing high-priority aquaculture research and extension projects for each region. IAC members represent different sectors of the aquaculture industry within a region and thus provide an open forum for input and program direction from the private and public sectors where they may express their point of view and thus influence program orientation. The TC consists of scientists involved in research and providing extension services, essentially from all states and territories within a region who work to determine priorities from a technical perspective.

CSREES also administers The Small Business Innovation Research Program (SBIRP) which offers grants that are competitively awarded to qualified small businesses. The program's purpose is to support high quality research proposals based on advanced concepts related to important scientific problems and opportunities in aquaculture that could lead to significant public benefit if the research is successful. The SBIR Program does not make loans and nor does it award grants for the purpose of helping businesses become established. SBIR Phase I grants are limited to $120,000 and a duration of six months, while Phase II projects may receive grants of up to $450,000 for two years. The SBIRP budget for fiscal year 2002 was $24 million.

The objectives of the SBIR Program are to:

- stimulate technological innovations in the private sector;
- strengthen the role of small businesses in meeting federal research and
- development needs;
- increase private sector commercialization of innovations derived from USDA-

- supported research and development efforts; and
- foster and encourage participation in technological innovation by small business firms owned by women and the socially and economically disadvantaged.

NOAA

Under a 1980 Memorandum of Understanding (MOU) reached between the Departments of Agriculture (USDA), Commerce (DOC) and Interior (DOI), the Department of Commerce, through the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS), and the National Sea Grant College Program (NSGCP), carried out aquaculture research and development on marine, estuarine, and anadromous species.

The NSGCP has conducted research, education, training and advisory services in aquaculture. Its programs to provide advisory services have been carried out in collaboration with the USDA's Extension Service. One example of a project that NSGCP funded was the creation, in February of 2000, of the *Sea Grant Gulf of Mexico Offshore Aquaculture Consortium*. This consortium was formed to create a collaborative, Gulf-wide, university-based interdisciplinary research program that will address social, environmental and technological issues that have plagued offshore aquaculture endeavours in the Gulf of Mexico.

Food Safety

USDA

The Technical Service Center (TSC) was established by the Food Safety and Inspection Services (FSIS) of the USDA to address the need for distribution of accurate and consistent information regarding food safety issues. The TSC serves also as the agency's center for technical assistance, advice, and guidance regarding the implementation of national policies, programs, systems, and procedures about what food safety. This includes implementation of the *Farm-to-table National Food Safety Strategy* within a HACCP framework.

FDA (Food and Drug Administration)

The Food and Drug Administration manages the Seafood Regulatory Program which oversees regulatory compliance in relation to fishery products. This includes two specific regulatory programs, both of which are voluntary and involve individual states and the industry:

- the Salmon Control Plan, designed to provide control over processing, plant sanitation; and
- the National Shellfish Sanitation Program (NSSP). The NSSP oversees adherence to the sanitation rules for harvest and production of fresh and frozen shellfish (oysters, clams and mussels) and for the production of fresh and frozen products.

Participants in the NSSP include the 23 coastal shellfish-producing states and nine foreign countries, of which Canada is one. The FDA conducts reviews of foreign and domestic molluscan shellfish safety programs. Foreign reviews are carried out under individual Memoranda of Understanding (MOUs), negotiated by the FDA with each foreign government to assure that molluscan shellfish products exported to the U.S. are acceptable.

In addition, the FDA conducts research in support of its seafood program. This research is directed to understanding the nature and degree of severity posed by various safety hazards, and other defects which may affect quality and the sector's economic integrity. Research is also carried out to finds means to detect and control these identified hazards.

Fish Health

USDA

The USDA's Animal and Plant Health Inspection Service (APHIS), which is the USDA's operational branch, provides aquaculture producers with joint programs for protecting the health of aquatic animals. APHIS programs currently provide services relating to important aspects of aquaculture, particularly with respect to disease, pest prevention, and wildlife damage management. As a result of the increase in global trade, APHIS has also become involved in facilitating the import and export of aquacultural products.

APHIS's activities relating to aquatic animal health are:

- providing diagnostic assistance to aquaculture producers when there are health problems in relation to their products;
- working with the Department of the Interior's U.S. Fish and Wildlife Service (FWS), the U.S. Department of Commerce's National Marine Fisheries Service, and members of the Joint Subcommittee on Aquaculture (JSA) to disseminate information and outline agency roles to best meet the aquaculture industry's animal health needs;
- endorsing animal health certifications for the exportation of live aquatic species and their products; and
- developing aquatic animal health monitoring and surveillance programs.

The following APHIS activities are related to veterinary products for fish:

- licensing domestic manufacturers of veterinary biologics to attest to the purity, safety, potency and effectiveness of their products;
- testing fish biologics at the APHIS National Veterinary Services Laboratories;
- issuing import permits for veterinary biologics produced in other countries;
- inspecting veterinary biologics production facilities, methods, and records;
- establishing and enforcing regulations for interstate movement of veterinary biologics;
- issuing documents to meet foreign countries' requirements for accepting export shipments of veterinary biologics produced by U.S. manufacturers;
- licensing veterinary biologics for the prevention, diagnosis, and/or treatment of diseases in aquatic animals; and
- investigating consumer complaints regarding biologics used in aquaculture.

The USDA initiated the National Animal Health Monitoring System (NAHMS) in 1983 to collect, analyze, and disseminate data on animal health, management, and productivity across the United States. NAHMS conducts national studies to gather data and generate descriptive statistics and compiles statistics and information from data collected by other industry sources. In 2003, the catfish industry will be review under the NAHMS.

Risk Management

The Non-Insured Crop Disaster Assistance Program (NAP) provides financial assistance to eligible producers affected by natural disasters. This federally-funded program, which covers aquaculture products as eligible crops, covers non-insurable crop losses and cases where planting is prevented by disasters. Natural disasters that it covers include any one of the following:

- weather conditions that cause damage, such as drought, excessive moisture, or hurricane;
- an adverse natural occurrence, such as earthquake or flood; or
- a condition related to damaging weather or an adverse natural occurrence, such as excessive heat or insect infestation.

NAP covers the amount of loss greater than 50 percent of the expected production, based on the approved yield and reported acreage.

Enterprises Financing (loans, guarantees, etc.)

USDA's Farm Service Agency (FSA)

The mission of the USDA's Farm Service Agency (FSA) is to stabilize farm income, help farmers, including aquaculturists, conserve land and water resources, provide credit to new or disadvantaged farmers, and help farm operations recover from the effects of disaster.

FSA offers:

- farm commodity financing programs;
- farm ownership incentive, operating and emergency loans;
- conservation and environmental programs;
- emergency and disaster assistance;
- as well as domestic and international food assistance and international export credit programs.

According to a U.S. study by Jarvinen published in 2000, FSA assistance plays a role in providing financial support for aquaculture, in states where freshwater as well as those where saltwater culture predominates.

NOAA's National Marine Fisheries Service (NMFS)

The NMFS fishing industry loan assistance programs also help to finance aquaculture development in certain states. Among these programs is the Fisheries Finance Program (FFP) which provides long-term debt financing for construction or purchase of aquaculture facilities.

Marketing and Exports - Imports

In addition, the USDA Agricultural Marketing Service (AMS) administers programs that facilitate the efficient, fair marketing of U.S. agricultural products, including aquaculture.

2.5 France

2.5.1 Production, economic impact and industry organization

French aquaculture production exceeded 267,000 tonnes in 2000, the second highest among European Union member countries (Table 2.6). However, this production was down slightly from 1995, with a negative average annual performance of –1.0%.

Table 2.6 French aquaculture production, 1995 - 2000

Species	Production (tonnes)					
	1995	1996	1997	1998	1999	2000
Pacific oyster	144,328	149,629	147,150	136,200	137,000	133,500
Blue mussel	49,194	49,962	52,350	50,800	51,600	58,000
Rainbow trout	48,924	50,625	50,482	44,498	38,602	41,143
Merditerranean mussel	15,000	12,000	11,000	10,700	10,900	10,000
Common carp	5,000	5,005	5,755	5,655	5,655	5,650
European sea bass	2,656	1,997	2,114	3,100	3,225	3,020
Roach	2,500	2,500	2,700	2,500	3,000	2,500
Sea trout	1,897	2,118	2,157	1,868	2,366	2,128
European flat oyster	2,662	2,500	2,500	2,300	2,000	2,000
European cross clam	200	200	250	500	1,466	1,470
European cockle	2,403	2,403	1,200	1,300	1,408	1,400
Tench	.	700	1,400	1,200	1,560	1,200
Gilthead seabream	984	486	1,312	1,500	1,193	1,180
Turbot	694	225	980	900	868	908
Marine shellfish nie*	197	197	400	800	618	600
Winkles nie	1,137	1,137	1,400	800	550	550
Atlantic salmon	894	800	950	760	750	502
Sheatfish	310	337	240	340	384	352
Northern pike	500	800	500	313	313	313
Rudd	-	-	300	300	300	300
Speckled trout	300	450	450	317	317	293
Pike-perch	400	300	300	200	200	200
Siberian sturgeon	160	160	190	350	109	90
European perch	-	251	251	101	80	80
Salmonids nie*	-	-	150	42	71	66
European eel	180	160	160	42	42	42
Arctic char	60	90	90	39	39	36
Common whitefish	-	-	30	30	30	33
Freshwater goby nie*	-	50	50	32	32	32
Kuruma shrimp	13	30	24	24	24	28
Herbivorous carp (Chinese)	-	20	20	22	22	22
Wakame seaweed nie*	100	54	54	50	20	20
Scallop	44	150	150	150	23	20
Freshwater fish nie*	-	-	1	39	9	20
TOTAL	280,786	285,526	287,243	267,855	264,850	267,767

Source : FAO Fishstat Database Version 2.3.2002.
*nie : not included elsewhere

This production is largely dominated by shellfish (shellfish culture): oysters (50%), blue mussels (22%) and Mediterranean mussels (4%). The only fish produced in significant quantities is rainbow trout, with 15% of total production in 2000.

The great diversity of species produced is definitley an important characteristic of French aquaculture. At least 32 species are cultured with production of at least a few dozen tonnes.

Total farm gate value for French aquaculture production was $644 million in 2000. This production can be divided into four subsectors:

- shellfish culture (shellfish farming in salt water);
- marine fishfarming (fish farming in salt water);
- continental fish farming (farming fish and other species in fresh water); and
- fish farming in ponds.

Shellfish farming

French shellfish farming, a traditional activity, is carried out essentially on lots granted by the government in public marine areas. Oysters and mussels accounted for more than 76% of French production in 2000, are marketed primarily from six regions: Lower Normandy, Brittany, the Loire, Poitou-Charentes, Aquitaine, Languedoc-Roussillon and the Marennes-Oléron basin, which alone accounts for 39% of oysters marketed.

In 2001, there were 52,600 concessions in public marine areas, representing 18,100 hectares and 1,570 km of post lines. Producers also operate 5,530 lots in private areas with a total area of 2,540 hectares.

In 1999, shellfish farming accounted for 16,500 jobs, of which 7,300 were full time. Most operations were family businesses (79%).

In 2000, France exported more oysters than it imported, 5,800 and 2,700 tonnes respectively. Trade in this species posted a positive balance of $16 million. However, imports of mussels for the same year (47,800 tonnes) far outstripped exports (5,500 tonnes), for a trade deficit of $73 million.

Marine fish farming

Marine fish farming began in the 1970s, and by 2000 had grown to some 52 producers on 60 production sites. For this same year, this subsector was estimated to employ 512 people with a total production of 5,800 tonnes of farmed fish and a farm gate value of $64 million. The three leading species raised are sea bass, gilthead seabream and turbot.

Producers in marine aquaculture have developed specifications that led to establishment of a quality charter designed to identify and enhance their products with a *Qualité - Aquaculture de France* (Quality - Aquaculture France) logo. Following the example of Scottish salmon marketed in France, they have also developed a red label for farmed sea bass.

Freshwater fish farming

Rainbow trout, the leading species produced in continental fish farming with 41,000 tonnes in 2000, posted farm gate sales of some $183 million. This output was produced by some 635 companies employing 1,580 people in 818 production sites. The vast majority of trout is produced in two regions: Aquitaine and Brittany, accounting for more than 47% of national production.

There are three markets for trout: 80% of trout sold are destined for direct human consumption, 12% for sport fishing and 8% for restocking rivers. The human consumption market has seen a shift away from the traditional portion-controlled trout (140 - 270 g) to larger fish suited to filleting (fresh or smoked) or production of steaks. Quite significantly, sales of portion trout dropped from 65% of total volume in 1991 to 16% in 1998.

Producers and all players in the areas associated with production of trout for human consumption adopted a *Charter of Trout Quality* a few years ago. This quality charter applies only to whole fresh trout and fresh finished products (cleaned trout, fillets and steaks). This policy is designed to provide consumers with a guarantee of total product quality. By complying with the standards established by this charter, processors and producers can obtain certification in the AFNOR NF-V.45.100 standard and the right to use the brand *La Truite, Charte Qualité* ® (Charter Quality Trout). The requirements cover production as well as processing, storage and shipping of the finished product, and labelling. It is interesting to note this entire system allows the product to be traced from the farm to the retail shelf.

Fish farming in ponds

Fish farming production in ponds can be described as extensive and traditional, focusing primarily on herbivorous fish (carp, roach, and tench) feeding on phytoplancton and zooplancton naturally present in the environment. There usually is no feed supplement, although some fish farmers may fertilize their ponds or add a grain-based supplement. Production for this traditional activity was close to 12,000 tonnes in 2000. Most of this production is used for restocking.

This production is quite often integrated into other economic activities, especially agriculture, and there were some 6,000 producers in 2000. That same year, the farm gate value was approximately $56 million.

France's leading aquaculture industry association is the *Fédération Française d'Aquaculture* (FFA), which represents 12 regional syndicates of fish and salmon farmers associated with the French Syndicate of Marine Aquaculturists (SFAM). Representing 95% of producers, FFA's mission is to:

- defend the profession's interests;
- conduct economic and social studies;
- generally promote production;
- coordinate the actions of members and their representation with public authorities;
- coordinate the actions of aquaculture syndicates between France and other countries; and
- represent affiliated syndicates with international, community and government authorities.

In recent years, FFA has specifically become involved in two areas of activity: developing markets for trout and defending fish farming in relation to environmental impact issues.

2.5.2 Governance structures

Sustainable economic development

Under the authority of the Ministry of Agriculture, Food, Fisheries and Rural Affairs (MAAPAR – the lead aquaculture agency), the Maritime Fisheries and Aquaculture Branch (DPMA) is responsible for economic initiatives, regulation, and monitoring the marine fisheries, aquaculture (marine and freshwater) and sea product processing sectors.

In the administrative area, DPMA:

- drafts regulations on occupancy of public marine areas allocated to marine cultivation;
- participates, in relation to European directives, with the Food Directorate in drafting regulations on shellfish consumer health protection;
- oversees application of these regulations with the technical support of the *French Institute for Research on Development of the Sea* (IFREMER), especially for health classification and monitoring of shellfish production zones;
- also takes responsibility for regulating animal health protection for shellfish and marine crustaceans; and
- monitors issues involving marine cultivation water quality.

In the policy and economics area, DPMA:

- determines the general thrust of marine fisheries and aquaculture policy at the national and European levels, as part of either the common or international fisheries policies;
- participates in policy on the use and enhancement of aquatic environments and wetlands;
- determines policy for investment and financing support for sector businesses;
- manages community aid to create and modernize marine cultivation operations as part of the *Fisheries Guidance Financial Instrument* (FGFI);
- also coordinates monitoring of the fish farming sector by regional aquaculture delegates and ensures monitoring of interprofessional organizations.

To implement this policy effectively, DPMA relies on decentralized agriculture, forestry and marine affairs services (regional and departmental branches, and CROSS (Centres régionaux opérationnels de surveillance et de sauvetage), which are regional monitoring and rescue operations centres.

It oversees the interprofessional organization of marine fisheries (national, regional and local marine fisheries and marine fish farming committees), of shellfish farming (national committee and regional shellfish farming sections), marine cooperation organizations and marine credit unions, the national interprofessional bureau for sea products and aquaculture (OFIMER), and IFREMER.

Environmental protection and water resource management

A Ministry of the Environment (ME) was created only fairly recently in France, which explains why few public servants report directly to this ministry. In regional or departmental branches, which are headed by a prefect responsible for the entire public service within his territory, public servants in various ministries, whose expertise and mandate were necessary for the application of ME legislation and regulations, have now been functionally assigned to ME. For example, a veterinarian reporting to the Departmental Branch of Veterinary Services with the Ministry of Agriculture, Food, Fisheries and Rural Affairs (MAAPAR) may be assigned to inspect fish farming facilities for application of the *Classified Facilities Act*, for which the ME is responsible (Gilbert, 1998).

Fish farms in France are subject to a number of laws, with the main ones being:

- The *Freshwater Fisheries and Fish Resource Management Act* (sections of the Rural Code) governing bodies of water (ponds, pools, etc.) connected to watercourses, canals and streams;
- the *Water Act* (1992) and its implementation orders regarding collection and runoff of surface and subterranean water; and
- the *Classified Facilities Act* (1976) and its implementation orders regarding environmental protection.

2.5.3 Recent developments and current issues

Marine Fisheries and Cultivation Guidance Act

The *Marine Fisheries and Cultivation Guidance Act* was passed in November 1997 (JORF, 1997). This founding legislation was introduced at a time when France's marine fisheries were emerging from a major crisis that had highlighted weaknesses in this sector and the need to modernize the businesses and social relations in the sector.

To ensure consistenty in the various facets of policies implemented, whether economic and social or centred on training or research, the act created a Senior Council on Fisheries, Aquaculture and Seafood Policy (CSO). This council is an advisory body that fosters regular dialogue between the MAAPAR and industry professionals, representatives of ministries involved, as well as researchers. The objectives of this CSO are to: ensure consistency of the various facets of marine fisheries and cultivation policy: resources - market - structures - research - training - employment - social relations; and ensure coordination of the actions of various organizations in the sector as well as a better association with research organizations.

The act also led to creation of the Interprofessional Sea Products and Aquaculture Office (OFIMER). The crises affecting the fisheries and aquaculture sector highlighted the need for an expanded interprofessional approach that integrates resource management and market realities. There was good reason to strengthen the Office's economic role to make it a genuine interprofessional office like those that exist in France's agricultural sector.

The creation of OFIMER supported:

- a rebalancing of the Office's executive in relation to the previous situation, to achieve parity between representatives upstream and downstream from the sector's economic activities;
- the creation of specialized committees, especially based on products or groups of products, or themes (quality), with authority delegated by the executive, to address specified issues more effectively. These committees may include members appointed from outside the executive;
- the transfer of stopgap unemployment funds to the Marine Fisheries National Committee (CNPM), to entrench the purely economic nature of OFIMER.

To carry out its mission, OFIMER funds studies and projects in applied research and development to achieve short-term results of joint interest for dissemination and direct application by workers in the fisheries and aquaculture products sector. To this end, OFIMER issues a call for project proposals based on the following themes:

- quality on board fisheries vessels;
- enhanced fisheries and aquaculture product freshness;
- food safety;
- development of new tools or processes;
- development of new products;
- commercialization of byproducts and by-catch;
- the specific needs of aquaculture in relation to the quality of finished products;
- socio-economic analyses; and
- legal and regulatory analyses.

The *Guidance Act* also recognized for the first time the key role of marine cultures for the economy of and employment in coastal regions. They are represented as carrying out this role at the CSO and OFIMER. The act affirms their agricultural nature. This clarification has allowed shellfish farmers to benefit fully from a number of agricultural provisions. Similarly, the creation of a type of navigation specific to this activity also helps affirm the independence of this sector. Furthermore, like fish marketing companies, operators will now have the opportunity to establish genuine rights relating to facilities located in departmental ports. Finally, the act recognizes the professional organization of shellfish farming and the ability to intervene to protect water quality.

Agricultural Guidance Act

The *Agricultural Guidance Act* of July 9, 1999 (JORF, 1999a) provides for the creation of territorial operating contracts (CTEs). This recognizes the many facets of the role of farmers and aquaculturists who, beyond producing foodstuffs, participate in land development, job maintenance and environmental preservation. Shellfish and fish farming activities are eligible for CTEs.

These individual contracts signed by a producer and government authorities (CTEs), based on an analysis of each operation covered, set out, for a five-year term, a project that includes mandatory measures to be implemented and desirable optional measures that may also be implemented. In return for meeting a certain number of socio-economic as well as enviromental commitments, the producer receives financial assistance based either on an investment subsidy rate or on supplementary costs or lost earnings attributable to the restrictive practices required as a result of these commitments. These include compliance with a quality-based approach, preservation of architectural or structural heritage, maintenance of landscape and environmental characteristics in cultivated areas and their environs, reduction of farming density, or waste management (JORF, 1999b).

Moratorium on coastal development

In 2001, the Ministry of Equipment, responsible in part for managing development of France's coastline, decreed a moratorium on all development affecting the first 100 metres of land extending inland from the coast. This decision was dictated by the growing number of haphazard development projects along the coastline that were generating conflicts between users of the coastline. This moratorium extended to shellfish farming.

Consequently, MAAPAR, in conjunction with all other ministries involved and in consultation with the relevant industry organizations, decided to review its coastal lands and seabed allocation policy (Bellot, 2002). The intent of MAAPAR and its partners is not to limit the growth of shellfish production, but to become more effective in ensuring sustainable development based on an updated land resource allocation policy. It must be noted that the current policy does not allow the French government to grant a seabed concession to a legally established company (corporate entity) but only to individual citizens of France. MAAPAR plans to change this situation by basing its new policy on the concept of a business while opening access to marine concessions to all citizens or companies within the European Union. These concessions would be granted for a period of 35 years and would be transferable. The new polocy should be announced in 2003.

Finally, to complete this section, the following points should be noted:

- *organic production* (a legally regulated designation) has been applicable to farmed fish since the release in August 2000 of the specifications govening this sector (JORF, 2000a);
- since the time of MAAPAR's order of November 15, 2000 (JORF, 2000b), the use of meat meal from land animals has been prohibited as feed for farmed fish;
- the new labelling in effect since January 1, 2002 provides better identification of all farmed fish: their name and the indication "farmed" as well as their country of origin must appear on the label when they are marketed.
- the MAAPAR foresees little development in terms of marine fish aquaculture in coastal zones due to the powerful conflicts with other users, notably with tourism; the MAAPAR is therefore re-evaluating its policy in this regard (Bellot, 2002).

2.5.4 Major programs and services provided

Financial support

As part of the Sector Plan for French Continental Aquaculture, MAAPAR may provide grants to aquaculture projects that meet the objectives of European policy. The criteria for support under the F*isheries Guidance Financial Instrument* program are presented in section 2.9.4.

Professional and regulatory support

In addition to administering certain provisions of Ministry of the Environment regulations, MAAPAR provides veterinary medicine services, engineering expertise and handles all interventions related to the safety of food and facilities.

CEMAGREF, a research body under the responsibility of MAAPAR, is involved in France's fish farming sector, especially in the area of environmental impacts.

Product safety

Policies and related regulations governing safety aspects of aquaculture products are almost entirely the responsibility of the European Community. Monitoring and enforcement of these regulations in turn are the responsibility of the national government of member states, specifically MAAPAR in France. Monitoring of contamination in shellfish zones is performed by IFREMER, while post-harvest inspection services are provided by MAAPAR. In the opinion of this latter ministry, producer self-monitoring of product quality is inadequate and the applicable legal framework is not sufficiently restrictive (Bellot, 2002).

Aquatic animal health

Like all member countries of the European Union, France monitors aquatic animal health under the authority of the Community System for Aquatic Animal Health (Directive 91/67/CEE on conditions for health policy governing the marketing of aquaculture animals and products, see section 2.9.5). In 1999, however, France adopted a decree expanding the list of animal diseases deemed contagious to include infectious hematopoietic necrosis (IHN) and viral hemorrhagic septicemia (VHS) for some species of fish as well as salmonid infectious anemia (SIA). That same year, France developed measures to battle diseases deemed contagious and provided funding to battle these diseases (JORF, 1999c).

Under this last ministry order, funds are paid to aquaculturists first and foremost to cover the costs incurred (analyses, health visits, etc.) to voluntarily qualify stock in order to obtain status as a farm or as being free of diseases deemed contagious, especially IHN and VHS. Government funding covers 50% of costs up to $2,000/year.

In cases of salmonid infectious anemia, infected stock must be destroyed. In this case, compensation equivalent to the value of destroyed stock is available to aquaculturists up to a maximum of $20,000.

2.6 NORWAY[4]

2.6.1 Production, economic impact and industry organization

Norway is the largest aquaculture producer in Europe with total production in excess of 487,000 tonnes in 2000 (Table 2.7). This production has almost doubled since 1995, when it amounted to 277,000 tonnes, with an average annual growth rate of 11.9%. Norwegian aquaculture is very heavily dominated by salmonids, which represent more than 99% of product volume. Atlantic salmon is the cornerstone of Norway's aquaculture industry, with 89.5% of national output, followed by rainbow trout raised in saltwater, which represented 10% of output. It should be noted that rainbow trout posted the fastest growth in production between 1995 and 2000, with average annual growth of 27.3%. In turn, salmon production rose at an average rate of 10.8% over the same period. At the same time, however, preliminary Norwegian statistics for 2001 show a decline in salmon production of some 11,000 tonnes from 2000.

Given the number of species produced and the concentration on two salmonid species, we must conclude that Norwegian aquaculture is not very diversified. But the Norwegian government and the private sector believe there is potential for new species development. Accordingly, private capital, and, in some cases, public money is being invested in diversification of the Norwegian aquaculture industry. Cod is considered to be the most promising new candidate for aquaculture, followed by haddock. Recent success in fry production has resolved one of the most important bottlenecks to commercial production of cod and an estimated 1,500 tonnes will be produced in 2002. Cod production is forecast to reach 8, 000 tonnes in 2005, 30,000 by 2010 and 400,000 between 2015-20. Cod sea ranching is also carried out. Atlantic halibut, Arctic charr, wolffish and blue mussels are also newly-farmed species.

Table 2.7 Norwegian aquaculture production, 1995 - 2000

Species	Production (tonnes)					
	1995	1996	1997	1998	1999	2000
Atlantic salmon	261,522	297,557	332,581	360,806	425,154	436,736
Rainbow trout	14,704	22,966	33,295	48,431	48,691	49,040
Turbot, Atlantic halibut, mackerel and pollock	444	397	585	814	668	1,018
Blue mussel	388	184	502	309	662	791
Arctic charr	273	221	350	189	498	168
Atlantic cod	284	191	304	199	157	167
Pacific oyster	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total	277,615	321,516	367,617	410,748	475,830	487,920

Source : FAO Fishstat Database Version 2.3. 2002.

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[4] Information nescessary for this section has been gathered with the valuable cooperation of Stephen Lanteigne of the Office of the Commissioner for Aquaculture Development.

Table 2.8 presents the findings of a study on the cumulative value of all Norwegian aquaculture production for 2000, published in a paper by the Norwegian Fish Farmers' Association (NFF, 2001). Based on this analysis, aquaculture production in 2000 generated a cumulative value of about $2.7 billion in Norway's economy.

Table 2.8 ***Cumulative value of Norwegian aquaculture production, 2000 (excerpted from NFF, 2001).***

Stage	Egg Production	Smolt Production	Cages	Bulk Shipping	Harvest/ Processing	Sales and Marketing	Shipping
Number	15-20 producers	250-260 producers	160 companies operating 790 sites	100 approved *wellboats*	150 processing & packing plants	120-150 merchants for domestic market & exports	Shipping to markets by Norwegian wholesalers
Volume	192 million salmon eggs + trout, charr & halibut	133 million smolts + 33 million trout and char fry	436,000 t salmon + 50,000 t other fish			20% of merchants sell 80% of products	
Value	**$17M**	**$170M**	**$1,908M**	**$34M**	**$304M**	**$170M**	**$135M**
Cumulative value	--	**$187M**	**$2,095M**	**$2,129M**	**$2,433M**	**$2,603M**	**$2,738M**
Proportion 100 %	0.6 %	6.2%	69.7%	1.2%	11.1%	6.2%	5.0%

Norway is the world's largest salmon exporter, shipping product to more than 100 countries (NFF, 2001). The vast majority of this product is exported fresh, primarily to European Union member countries, in declining order, Denmark, France and Germany. Most trout produced are also exported, but these are frozen and destined primarily for the Japanese market (Directorate of Fisheries, 2001).

In 1999, total direct employment in aquaculture production was estimated at 4,138 jobs.

In the early 1970s aquaculture was non-existent. It was seen as a source of potential income for farmers. In the mid-70s a policy decision was taken by the Ministry of Fisheries to integrate the fisheries and aquaculture sectors. This philosophy was adopted because of similarities between both sectors and the need to strengthen economic development and increase wealth in coastal rural areas. The Ministry of Fisheries saw it as a natural symbiosis of the two sectors.

The National Federation of Fisheries and Aquaculture Industries (FHL) was created in 1991 to advance a number of broad issues such as industrial policy, salary and working conditions, health, safety and the environment. The FHL is an umbrella organization for the Federation of Norwegian Fishing Industries (FNL), the Norwegian Fish Farmers' Association (NFF) which jointed the FHL in 1994, the Norwegian Fish Feed Producers' Association (NFPF) and the Norwegian Association of Herring Meal Producers (SL), which both joined the FHL in 1997.

According to Ward (2000), the entire integration process was voluntary and private-sector driven. The Federation of Norwegian Fishing Industries played the lead role in convincing the

Norwegian Fish Farmers' Association that it was in their mutual interest to form a single advocacy group (FHL). Once the main fish processing and fish farming organizations were united, the next logical step was for the fish meal producers and the feed producers to join ranks.

The general consensus is that the formation of the FHL has been a positive development for both the industry and the public sector. The FHL has effectively united the processors (of wild and farmed fish), fish farmers, feed producers and meal producers to become a highly effective advocacy group. The mandate and structure of the organization clearly places the responsibility for "industry-wide" issues with the FHL, while sector-specific issues are normally handled by the respective industry associations (Ward, 2000).

Effective in 2002, two important changes took place that brought the fisheries and aquaculture industries closer to full integration:

- Each association agreed to relinquish its incorporated name, for example, Norwegian Fish Farmers' Association, and assume the name of the Federation of Fishing and Aquaculture Industries (FHL). Furthermore, the FHL is to be structured into four divisions, processing, fish farming, meal production, and fish feed production. Each of the divisions will have its own board as well as representation on the FHL board (see Figure 2.3).
- The FHL will take over the responsibility for collecting levies and will pay each division a portion of the proceeds for its operating costs.

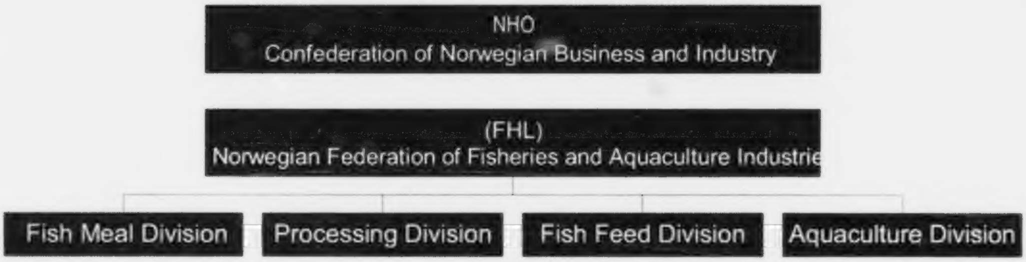
NHO
Confederation of Norwegian Business and Industry
(FHL)
Norwegian Federation of Fisheries and Aquaculture Industri
Fish Meal Division
Processing Division
Fish Feed Division
Aquaculture Division

Figure 2.3 Fisheries and Aquaculture Sector Industrial Organization Structure in Norway (from Ward Fisheries Consultant Inc. 2000).

2.6.2 Governance structures

The Norwegian government strongly encourages development of remote communities and aquaculture is recognized as a good economic tool for this purpose.

The Ministry of Fisheries is the lead agency for aquaculture. The Ministry is responsible for issuing aquaculture licences and for control of the industry. Anyone wishing to become involved in fish or shellfish farming must obtain a licence. Aquaculture is strictly controlled by a number of laws and regulations administered by the ministries of Fisheries, of Environment, of Agriculture (disease control and regulations), as well as the Ministry of Local Government and Labour. There is close collaboration between these ministries and the aquaculture industry.

Legal Framework

The following are the principal acts and regulations, administered by the Ministry of Fisheries governing the aquaculture industry in Norway:

- *Act No. 68 of June 14, 1985 relating to the Breeding of Fish, Shellfish, etc. The Aquaculture Act*). The purpose of this act, which contains provisions for the issuing of licences, is to contribute towards the balanced and sustainable development of the fish-farming industry and to help it become a profitable and viable industry at the regional level (Fisheries Directorate, 1985).
- *Act No. 54 of June 13, 1997 relating to Measures to Counteract Diseases in Fish and Other Aquatic Animals* (*The Fish Diseases Act*) whose purpose is to prevent, control and eradicate infectious diseases in fish and other aquatic animals (Fisheries Directorate, 1997).
- Regulation of December 18, 1998 relating to the Establishment and Operation of Fish Farms and to the Putting into Place of Measures to Prevent Disease (Regulation Concerning Operations and Diseases). The regulation covers the establishment and operation of all types of fish farms, with certain exceptions governed by other special regulations. This regulation governs the design and operation of fish farms, including provisions for protection of the environment. It requires that fish farms respect the conditions of their licences and other relevant directives in a manner that meets technical, environmental and biological standards (Fisheries Directorate, 1998).
- Regulation of December 20, 2000 relating to the Allocation, Establishment, Operation of Fish Hatcheries for Salmonids and Other Freshwater Fish and to Disease Prevention Measures (Fish Hatchery Regulations) (Fisheries Directorate, 2000a).
- *Act Regarding the Regulation of Exports of Fish and Fish Products* (Fisheries Directorate, 1990) and its regulations (Fisheries Directorate, 1991); this act gave rise to the creation of a Fish Export Council, to an approval process relating to exports, the establishment of minimum price criteria for sales and exports, as well as the putting in place of an annual fee payable to the Export Council by each exporter (discussed below in the section on Programs and Services).
- In 2000, a new *Sea Ranching Act* was adopted (see next section).

As described by Rogers (2000b) the following acts also have a direct and significant impact on aquaculture development in Norway:

- The *Pollution Control Act* whose aim is to protect the environment against the detrimental effects of emissions and waste that may originate from fish farms. Enforcement of the act has, to a large extent, also helped increase knowledge and awareness of environmental effects caused by individual enterprises at the local level and by the industry as a whole. The Ministry of the Environment's Pollution Control Authority issues permits required under this act.

- The *Planning and Building Act* whose scope includes all the area beyond the low-water mark; this act was designed to solve user conflicts within the coastal zone. The act defines the scope of municipal and county-municipal planning powers and is based on the assumption that area authorities and municipalities will collaborate to find solutions. The act regulates site selection in relation to planning by local governments; it is administered by the Ministry of Local Government and Labour.

Aquaculture licensing process

Figure 2.4 illustrates how applications for fish farming licences are dealt with. Government representatives consider the process to be simple, by virtue of the "single window" approach that the Fisheries Directorate has put in place at the regional level. Applicants are required to fill out a single form, which is used by all the authorities that are involved. The Fisheries Directorate is currently working to develop an electronic application form that may be filled out and submitted at any time during the 24 hours of a day. While there are currently no service standards established, the Ministry foresees implementation of some general standards. The time that it may take to obtain a decision on an application varies greatly, and may be between two weeks and several years. Municipal administrations may be the cause of the delays as several of them are in the process of preparing coastal management plans. As municipalities must hold public hearings and present their own evaluation for each licence application, they slow down the process in order to have the time to establish their zoning plans in advance of this. In February 2001, 151 out of 251 municipalities had adopted coastal zoning plans (Fisheries Directorate, 2001).

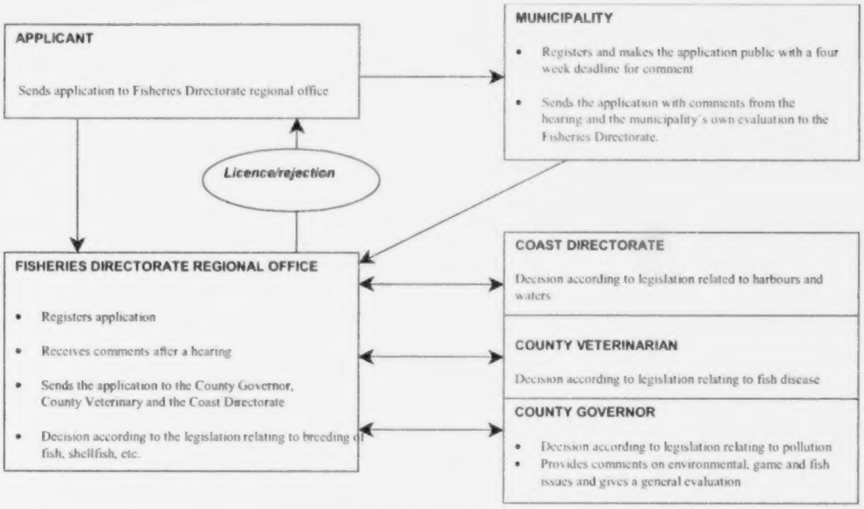
APPLICANT
Sends application to Fisheries Directorate regional office
MUNICIPALITY
• Registers and makes the application public with a four week deadline for comment
• Sends the application with comments from the hearing and the municipality's own evaluation to the Fisheries Directorate.
Licence/rejection
FISHERIES DIRECTORATE REGIONAL OFFICE
• Registers application
• Receives comments after a hearing
• Sends the application to the County Governor, County Veterinary and the Coast Directorate
• Decision according to the legislation relating to breeding of fish, shellfish, etc.
COAST DIRECTORATE
Decision according to legislation related to harbours and waters
COUNTY VETERINARIAN
Decision according to legislation relating to fish disease
COUNTY GOVERNOR
• Decision according to legislation relating to pollution
• Provides comments on environmental, game and fish issues and gives a general evaluation

Figure 2.4 Process for Handling Applications for Fish Farming Licences in Norway.

2.6.3 Recent developments and current issues

At the beginning of 2001, the Government of Norway stressed, in a new National Aquaculture Policy Statement, that few economic sectors demonstrate better than does aquaculture that Norway is a society with good prospects for the future (Gregussen, 2001). To ensure continued growth of the aquaculture industry, the Ministry of Fisheries decided to provide active public sector management in coastal areas based on a solid legislative and administrative framework, an effective transport network, and provision of good public services to the aquaculture industry as a whole and to its workforce in particular. These measures are based on the principle that aquaculture policy is not only based on matters relating to licences and customs tariffs.

The key components of this policy statement are :

Market access

- The Norwegian government's aim is to ensure that there is a stable, long-term and predictable framework for salmon exports to the EU market through the renewal of the existing salmon export agreement, which includes provisions regarding export duties, the establishment of minimum prices and limitation of annual growth of salmon exports.

Sustainable growth

- Norway needs to continue to develop environmentally sound production. In Norway, discharges of nutrients by the industry are no longer considered to be a problem for the surrounding environment. Nevertheless, monitoring of discharges of nutrients and control of the use of chemicals and therapeutants must continue as the industry develops further. With respect to the environmental impact of fish farms, the main issues that must be dealt with are combatting salmon sea lice and controlling escapes of farmed fish.
- To guarantee the safety of Norwegian seafood products, the government will continue to control concentrations of residues from therapeutants, and will give priority to upgrading control systems and analytical tools. These will include the adoption of new methods for detecting algal toxins in shellfish.
- Salmon and trout farming now produces almost twice as much fish meat as the total amount of meat produced by Norwegian agriculture. In spite this, fish farming accounts for less than two per cent of the total consumption of antibiotics in Norway. The Norwegian authorities consider Atlantic salmon to be their healthiest animal species. With respect to fish health, Norway plans to continue to focus on prevention of infections by intensifying its research efforts.

Active public-sector management

- A new active public-sector management framework will be put in place by providing space in the coastal zone for existing production but also for new production such as shellfish and also by encouraging the culture of several species on one site (polyculture).

- Under this management framework, the government will continue to play an active role in adapting the growth of salmon and trout production to market trends in the next few years mainly through limits on feed quotas. In this regard, the legislation has two sections: one for salmon and one for other aquaculture species. Quantitative limits are used to control farm production and the growth of the salmon industry. The maximum number and distribution of licences is controlled. The size of a salmon farm is limited to a maximum of 12, 000 cubic metres. The current limit of a feed quota is set at 840 tons of feed a year per licence. There are no limits imposed on other aquaculture species. Furthermore, the system for regulating production is to be improved, based mainly on licences and feed quotas, but also taking into account the carrying capacity of the individual site. In practice, this means that an aquaculture operation will only be able to make complete use of its feed quota if the site has sufficient environmental carrying capacity.
- With respect to license ownership, in theory any aquaculture company can own up to 10% of the licences. If a company requires more licences it must obtain a permit which will allow it to acquire 10 to 15 % of all the licences. If it wishes to acquire additional licences, it must apply for a second permit, which would enable it to hold between 15% and 20% of all the licences. For instance, Marine Harvest (Nutreco) holds 12 % of the salmon licences in Norway. However the Ministry of Fisheries has placed a freeze on any further concentration within the industry as the government intends to establish general rules concerning restrictions on ownership of salmon and trout farms in the near future.
- In 2000, in co-operation with the Norwegian Fish Farmers' Association and other users of aquaculture data, the government launched a project to develop an electronic system for reporting all information relating to aquaculture required by the public authorities.
- No salmon licences have been issued since 1985. Although it would be possibie for Norway to increase production within the framework of the existing licences, for example, by raising feed quotas, the government decided to allocate a new series of salmon licences in 2002. Forty new licences will be issued with 10 (25%) of these being reserved for Finmark, an area in the most northernly part of the country. This policy of equitable distribution is aimed at maintaining the fish farming industry's profitability and at supporting economic development in remote coastal areas. Except for those for salmon and trout farming, all licences are free of charge. The cost of a new salmon or trout licence is $1 million with an additional $2,500 administrative fee.
- There has been a broad-based public debate in Norway about the taxation and distribution of future profits from fisheries and aquaculture enterprises. Proposals have been made to introduce special taxes on fish farming licences, for example, a tax based on the size of an area or a tax when licence rights change hands. Before proceeding, the Norwegian government decided to thoroughly examine the legal, economic and policy principles underlying use of the coastal zone, and the effects of the proposed taxes on the international competitiveness of the industry.
- The government has appointed a special committee responsible for co-ordinating the work carried out by various public authorities with respect to the aquaculture industry. Headed by the Minister of Fisheries, the committee includes representatives of the ministries involved, of the Research Council of Norway and of the Norwegian Industrial and Regional Development Fund. In carrying out its work, the committee is making a concerted effort to promote a solid dialogue with

representatives of the aquaculture industry and with the regional elected bodies along the coast.

New opportunities

- In Norway, the view is that sea ranching is opening up new opportunities. At this stage, the species that are considered to offer greatest potential are lobsters and scallops. In 2000, a new *Sea Ranching Act* for sedentary species was passed by the Norwegian Parliament. The act provides licence holders with an exclusive right to recapture, over large areas, species that have been cultivated. The act allows non-licence holders access to and use of areas, provided that they do not make use of fishing gear that destroys the sea bottom (Fisheries Directorate, 2000b). The law is to be enforced by means of regulations that are expected to be finalized towards the end of 2002.

Innovation Program

- The Norwegian government recognizes that, at least for a transitional period, an injection of public funds will be needed to help the development of marine industries that are not yet commercially viable, such as shellfish production and new marine finfish production. As a result, in 2000 the government decided to launch an Innovation Program for the Commercial Exploitation of Marine Resources. With a total budget of $14.5 million, the program is part of a joint effort by the ministries of Fisheries, of Local Government and Regional Development, and of Trade and Industry. The program focus will be on further development of farming of marine species and projects that combine elements of fish farming and sea ranching.

Expanding the public administration framework for the aquaculture sector

- A comparison of aquaculture with other important sectors in Norway shows that an absolute minimum of public administrative resources are available to the aquaculture industry. At the same time, the administrative authorities see their responsibilities increasing as they are given new, essential functions such as quality control, regulation of production, and management of the coastal zone. According to some observers, the lack of administrative resources is having the effect of restricting development of the industry. The Norwegian government hopes to put into place a modern administrative system for the aquaculture industry, with expertise and capabilities that are suited to the industry's needs, and to ensure that the system can evolve in tandem with growth of the industry.

A New Aquaculture Act

- The Norwegian government is currently undertaking a complete review of the *Aquaculture Act*, and intends to submit a new draft act to provide a legal basis for active management of the industry, taking into account environmental considerations, food security, management of the coastal zone and required control of production. The objective is to provide all stakeholders in the industry with a consistent set of rules within a single act.

2.6.4 Major programs and services provided

The information contained in this section comes from three main sources: firstly, from discussion with staff from the Aquaculture Section of the Norwegian Fisheries Directorate; secondly, from the web sites of the organizations mentioned below; and, thirdly, from a document submitted by the Norwegian government to the European Union in 2002, which provides detailed explanations about the programs, services, taxes, incentives, etc. for the Norwegian aquaculture industry.

Research & Development

The Research Council of Norway (RCN) supports aquaculture R&D by providing basic grants to research institutes, by carrying out projects and strategic programmes in collaboration with universities and research institutes, and by providing individual study grants. One program targets the production of aquatic organisms in particular, with funding being provided for up to 50% of the total cost of an approved project. Evaluation of requests for funding is carried out project by project, in what is a very competitive process. A Science and Industry Committee decides which projects will be supported. In 2001, a total of $4 million was granted for salmon projects, which represents 38.7 % of total project costs.

Aquaculture is one of the three core areas of research at the Norwegian Institute of Marine Research (NIMR). The core activities of NIMR are environmental effects of aquaculture, well-being and fish health, safe and healthy food products, and further development of marine species in aquaculture (NIMR, 2002a).

The NIMR's Department of Aquaculture directs four programs, ecology and genetics of cultured species, fish health, marine species and salmonids. In 2000, it had a staff of 90 employees and a total budget for aquaculture of $10.5 million (NIMR, 2002b). In 2001, the NIMR had a staff complement of 107 person-years and its annual budget for aquaculture amounted to $16.4 million.

While the Ministry of Fisheries does not provide any R&D funding program directly to the aquaculture industry, it does provide funds for R&D to the RCN and the NIMR.

The Fishery and Aquaculture Industry Research Fund (FAIRF) was established on January 1, 2001, under the the *Act of July 7, 2000 Concerning the Financing of Research and Development in the Fisheries and Aquaculture Industry* and its *Regulation of October 11, 2001*. The Minister of Fisheries is responsible for the Research Fund.

The Fund's objective is to increase financial participation of the fisheries and aquaculture sector in R&D activities, with the focus being on adding value, improvement in meeting environmental requirements and innovation. The Fund provides direct support to all research organizations whose projects contribute to achieving these objectives.

Funding of activities is based on the same principles as the funding of the Norwegian Seafood Export Council (NSEC), which administers the Fund. Thus, activities carried out under the Fund are financed through the imposition of a levy on all exports (flat rate of .003 per cent of the export value), which is added to the export tariff that is used to finance all of the NSEC's activities (see section below concerning merchandising and export).

In the first year, 2001, a total of $14.6 million in levies was collected, of which only $2.75 million was allocated to R&D projects, notably those on Infectious Pancreatic Necrosis (IPN) disease. All funds were distributed through the Research Council of Norway (RCN).

The Norwegian Institute of Fisheries and Aquaculture (NIFA - Fiskeriforskning) is a research company owned by NORUT Group Ltd. (51%) and the Norwegian Ministry of Fisheries (49%) (see Figure 2.5). NORUT Group Ltd. consists of five research institutes, based in Tromsø and Narvik. The company is owned by the University of Tromsø and the Narvik Regional College, among others.

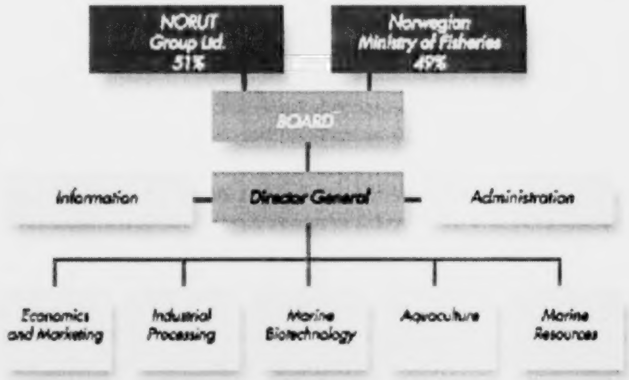

Figure 2.5 ***Organizational Structure of the Norwegian Institute of Fisheries and Aquaculture (Source NIFA).***

NIFA's objectives are :

- to carry out research and development for the fisheries and aquaculture industry in Norway, with a view to making the best possible use of marine resources;
- to promote and disseminate to industry and the general public, findings and knowledge resulting from research; and
- to provide advice to the authorities on various fishery-related matters.

NIFA collaborates closely with the University of Tromsø, in particular with its College of Fishery Science of Norway. This collaboration is carried out through the Aquaculture Research Station in Tromsø, whose research program is focussed on salmonids (Atlantic salmon, rainbow trout and Arctic charr) and coldwater marine fish species (Atlantic cod, polar cod, capelin, wolffish and several species of flatfish). Work on crustaceans (e.g. king crab) and other marine organisms (e.g. sea urchins) is also being carried out.

NIFA's research activities encompass:

- management and controlled reproduction of broodstock;
- larval rearing and 'seed' production;
- feeding, nutrition, feed development and fish quality;
- fish diseases, immunology, parasitology and vaccine development; and
- development of on-growing systems and technology testing.

Work includes investigations of how environmental factors (e.g. temperature, photoperiod, water quality, stocking density and anthropogenic factors) influence feeding, growth, sexual maturation and reproduction, often with the aim of developing improved rearing and feeding practices to be used in aquaculture businesses. It also carries out feed evaluation and growth trials in collaboration with private sector companies.

Research activities also include the development of technologies for trapping, live storage and transport of fish, and the development of larval rearing methodology and on-growing systems (e.g. raceways and water re-use systems). The testing of feeding systems and other types of equipment is carried out under contract.

Fish health research is mostly directed towards prevention and control of disease in salmonids and marine fish through the development of vaccines against major fish diseases and the testing of immunostimulants and probiotics.

In 2001, the Norwegian government designated Tromsø as the regional centre for Norway's efforts in cod fish farming and it specifically assigned to NIFA the responsibility for the breeding and genetics program.

In 2000, NIFA's budget was mainly provided by the Research Council of Norway (41%), the Norwegian Ministry of Fisheries (28%) and from other sources, which include industry (see Figure 2.6). The total income for that year was $14.1 million.

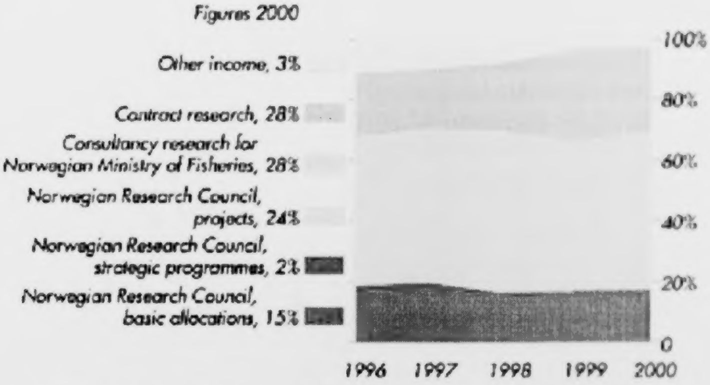

Figure 2.6 **Revenues and Funding for the Norwegian Institute of Fisheries and Aquaculture (Source NIFA).**

Aquatic Animal Health

There is no official national aquatic animal health program in Norway, nor does the state provide any compensation for financial losses resulting from measures taken such as eradication and destruction of fish (prescribed in Section 23, *Fish Diseases Act*).

The National Centre for Veterinary Contract Research and Commercial Services (VESO), established in 1998, retails veterinary vaccines, and is involved in various activities related to fish diseases. VESO is owned by the Ministry of Agriculture (51% ownership) and SIVA, the Industrial Development Corporation (49% ownership), which is a Crown corporation owned by the Ministry of Local Government and Regional Development. While SIVA is also co-owner of more than 60 innovation centres in Norway, these are not involved in the aquaculture sector.

In 1996, the name of the State Veterinary Laboratory Services was changed to National Veterinary Institute (NVI). The NVI is the Ministry of Agriculture's official scientific institution for veterinary research, diagnostic, analytic and other support services. There are three sections within the NVI :

- the Department of Animal Health;
- the Department of Aquatic Animal Health, which includes five regional laboratories;
- and the Department of Feed and Food Hygiene.

The NVI provides diagnostic and scientific services to the agricultural industry. In some cases, these services are free, but in other cases, depending on the pathology to be treated, the industry must pay a fee, which is adjusted on a regular basis. As of January 1, 2002, the NVI no longer issues health certificates in connection with the export of living organisms (eggs) or fish for consumption.

Payments made by the aquaculture industry to the NVI for diagnostic services in 2001 amounted to approximately $175,000 while the institute spent about $1.2 million on aquatic animal health research in 2001.

It should be mentioned that the NVI was officiallly designated by the Organisation Internationale des Épizooties (OIE)[5] as the international reference laboratory for diagnosis of Infectious Salmon Anaemia (ISA).

Farm insurance program

Contrary to the situation for the agricultural sector, there is no publicly-funded farm insurance program available for aquaculturists in Norway. Currently, aquaculture sector growers are covered by private insurance companies. They determine their own needs, with the insurance premium being based on the coverage. The Norwegian parliament is currently debating the desirability of having such a program for the aquaculture sector. The view of the Ministry of Fisheries is that government should not offer compensation because it could be perceived to be a subsidy and lead to trade barriers in export markets. If the government decided to offer insurance programs to the aquaculture sector, it should not design these based on those that have been put in place for agriculture.

In 2000, aquaculturists paid approximately $30.6 million in insurance premiums. Approximately $21 million was paid to them to compensate losses, for a ratio compensation/premium of 68% (Fisheries Directorate, 2001).

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[5] The OIE is the international standard-setting organization for animal health, zoonoses and animal welfare.

Aquaculture food safety program

Norway follows the EU regulations regarding food quality standards and the certification process for therapeutants and pesticides, with a zero-detection limit for permitted levels of therapeutants and pesticides in aquaculture products at the time of harvest (Maroni, 2000). There is no publicly-funded program such a Hazard Analysis Critical Control Point (HACCP) on-farm program for aquaculture food safety.

With respect to mussel culture, growers are required to pay for all biotoxin testing and monitoring services.

Public Financial Support for Industry Development

There is no National government funding specifically dedicated to enterprise development for the salmon aquaculture sector. Government funding is shifting from infrastrucutre funding programs to software programs (that is, support for a market-based, knowledge economy). However, companies interested in farming new aquaculture species can make use of regional development funds, such as the Norwegian Industrial and Regional Development Funds (NIRDF). Although not specifically for aquaculture, there is also financial assistance for businesses located in remote areas, with the maximum funding being 35% of the total cost of a project. This assistance consists of loans, guarantees and grants.

The NIRDF is the owner of *NIRDF Invest AS* -a sister company administered by a board that operates entirely on commercial principles-, which, from 1996 to 2001, purchased shares in the companies listed in Table 2.9.

Table 2.9 Norwegian Government Ownership in Private Aquaculture Sector Companies

Enterprise	NIRDF Invest AS Amount of investment
Aqua Gen (egg producer)	$ 4.9 million
Fjord Seafood ASA	$24.9 million
Hydrotech-Gruppen AS	$ 2.6 million
Leroy Seafood Group AS	$ 5.9 million
Pan Fish	$17.3 million
Total	$55.5 million

In addition, the state subsidizes the transportation of goods to and from remote areas (mainly the northernmost Norwegian counties). This support is negligible and only a few companies in the salmon sector have benefited from it in recent years. The total amount of subsidies paid for the transport of salmon was $105, 250 in 2001.

Capital/Venture Funds

North Norwegian Growth (NNG) is an investment company partly owned by private companies and partly by government institutions and agencies. It provides resources in the form of venture capital (no grants) and know-how to small and medium-sized companies with potential for growth and profitability. Its ownership interest is usually between 10 to 49% and it is represented on the boards of directors of firms it finances.

Marketing and Exports

The Ministry of Fisheries does not provide any programs to assist with marketing. Marketing of fish is the responsibility of the Norwegian Seafood Export Council (NSEC), which is the marketing body for fisheries and aquaculture products. It main function is to promote awareness concerning Norwegian seafood in domestic and foreign markets. It was established by the Storting (Norwegian Parliament) on July 1, 1991 under the *Fish Export Act*. The Council also plays an advisory role for the Ministry of Fisheries. It is governed by a Board of Directors that is elected for a two-year term by the Ministry of Fisheries, based on advice from the organizations within the fisheries and aquaculture industry.

The legislated mandate of the NSEC is: to provide certification or exporters, disseminate information to industry, and market Norwegian seafood products within the country and internationally. With its headquarters and administrative offices located in Tromsø, the Council also has representatives in Germany (Hamburg), France (Paris), Spain (Madrid), Brazil (Rio de Janeiro), USA (Boston), Japan (Tokyo), and China (Hong Kong and Beijing).

The NSEC is entirely financed by the industry through statutory fees or levies on all seafood exports. These are established on an annual basis and can range between 0.75% and 3.0%, depending on EU requirements.

The NSEC's activities are focussed on four areas (NSEC, 2002):

- Marketing. The marketing activities are aimed at increasing the demand for Norwegian seafood.
- Market information. NSEC prepares statistics and conducts market analyses for seafood intended for exporters and industry stakeholders, to provide the best possible information to be used in decision-making by industry, the responsible authorities and by the NSEC's internal services.
- Market access. One of the goals of the Norwegian fisheries industry is to be positioned at least as well as its competitors, in terms of competitiveness and of access to main markets. The NSEC has established a system whereby industry participants can collect information about import quotas, tariffs and trade conditions in various markets.
- Public Relations. As the marketing agency for the fisheries industry, one of NSEC's objectives is to preserve the Norwegian fishing industry's reputation. Through the positive exercise of its influence and by establishing action plans, the NSEC is contributing towards enhancing the reputation of Norwegian seafood at home and abroad.

The Export Credit Guarantee Institute (GIEC) offers long-term export guarantees. Its sister company, GIEK Credit Insurance Ltd., provides short-term credit insurance. Both organizations, which are under the Norwegian Ministry of Trade and Industry, focus in particular on covering risks for small and medium-sized export companies. Fish, metals and paper (raw material) represent 75% of the export volume.

In 2001, more than 4,000 special credit limits were granted. The premiums paid by beneficiaries amounted to $4.2 million (mostly for fish exports to Western Europe), and payments of claims amounted to $3.4 million, resulting in an annual profit for that year of $470,000.

Infrastructures

Despite the fact that there is no particular program in place for maintaining port infrastructure that is of strategic importance for aquaculture, there is a more general program directed towards the fisheries products sector. The program is cost-shared between the Ministry of Fisheries and local governments, whereby each party covers up to 50 per cent of the cost of port infrastructure projects.

Education and Training

The mandate of the Norwegian Fisheries Industry Skills and Resource Centre (SRCNFI) is: to develop the know-how and skills of those involved in the fisheries and aquaculture industry, to encourage young people to obtain training and pursue a career within the sector; to improve the situation of women in the industry and to promote gender equality in the fisheries industry. This Centre is run by a Board of Directors consisting of representatives from the Norwegian Fishermen's Association, the Norwegian Fish Farmers' Association, the Norwegian Fishing Industry Federation and the Norwegian Trade Union Federation as well as the Norwegian College of Fishery Science, the Centre for Gender Equality and the Norwegian Association of Fishemen's Wives.

2.7 NEW ZEALAND

2.7.1 Production, economic impact and industry organization

In 2000, total New Zealand aquaculture production was 85,640 tonnes, an increase of more than 15,000 tonnes from 1996, which translates into an annual growth rate of 4% over a six-year period (Table 2.10). The major species cultivated is the green mussel (*Perna canaliculus*), which accounted for 89% of total production. The farm gate value of this mussel production was $45 million in 2000.

Other species farmed are chinook salmon (7%) and Pacific cupped oysters (4%). It should be mentioned that with respect to salmon, only chinook is successfully farmed in New Zealand and farming of rainbow trout is not authorized. Salmon farming occurs only on the South Island either in sea cages or in freshwater raceways. Annual production from salmon farms has remained static over the period 1995-2000 at an average volume of 5,500 tonnes.

According to the producers, the salmon industry's existing production capacity is approximately 10,000 tonnes, with a capability for expansion to at least 14,000 tonnes. Currently, there are 14 on-growing sites and 12 hatcheries/freshwater sites, with an estimated juvenile fish production capacity of 10 million smolts.

Total aquaculture production was worth more than $80 million in sales in 2000 (farm gate value) and generated more than 7,000 jobs.

Table 2.10 New Zealand Aquaculture Production for the Period 1995-2000

Species	Production (tonnes)					
	1995	1996	1997	1998	1999	2000
New Zealand mussel	62,519	65,000	65,500	75,000	71,000	76,000
Chinook salmon	5,000	6,400	4,350	5,807	5,700	6,140
Pacific cupped oyster	2,872	3,400	7,000	13,000	14,950	3,500
TOTAL	70,391	74,800	76,850	93,807	91,650	85,640

Source : FAO Fishstat Database Version 2.3. 2002.

The New Zealand Seafood Industry Council (SeaFIC) promotes the interests of all sectors of the fishing industry, including those of aquaculture. SeaFic provides economic information and advice, co-ordination of industry resources, and enhancement of the industry's profile in the community. SeaFIC is industry-owned. It is financed through a statutory levy collected on all fish landed and processed by New Zealand industry. In 2002, SeaFIC's major priorities included enhancing property rights for the aquaculture sector.

The salmon industry is represented by the New Zealand Salmon Farmers Association, which represents growers of more than 98% of all the salmon farmed in New Zealand.

The New Zealand mussel industry has adopted the principle of *co-operating to compete*: whereby key generic issues that are strategically significant, such as core production techniques, environmental management, generic market research and market development programs are funded by otherwise competing individual production and processing companies.

Those processors and producers collectively own and manage the NZ Mussel Industry Council Ltd (NZMIC Ltd).

In 1999, the NZMIC introduced an *Environmental Code of Practice*, whose purpose is:

- to raise awareness among industry members and other interested parties about the environmental effects of the mussel industry, practical options for addressing these effects and about relevant environmental legislative/regulatory requirements;
- to implement a procedure for ongoing environmental monitoring that may be used to assess whether the Code is achieving its objectives, which should lead to a process for improving the environmental performance of individual members and of the industry as a whole; and
- to satisfy the requirements of the *Resource Management Act* which states that each individual has a duty to prevent, counter or mitigate any adverse effects on the environment from any activity.

The New Zealand Seafood Training Organization (SITO) facilitates competence-based training for all areas of the industry, including both specialized, skills-based training, such as for seafood processing as well as more generic training, for example, relating to management and information technology skills. To this end, SITO:

- works closely with the industry to establish and maintain training standards and qualifications with respective to marine food products;
- accesses government training funds for the industry;
- co-ordinates the work of training providers in relation to the training needs of companies; and
- works with individual companies to analyze and fill their training needs.

2.7.2 Governance structures

The NZ Ministry of Fisheries is the lead agency for aquaculture.

At present, an individual who would like to establish a marine farm in waters below the high water mark, must obtain two authorizations. Firstly, they require a resource consent (or a certificate of compliance) issued by the relevant regional council and, secondly, a marine farming permit issued by the Ministry of Fisheries. The Ministry of Fisheries can decline such an application but may only issue a marine farming permit after a resource consent (or certificate of compliance) has first been issued by the regional council.

On-shore farming is controlled by the Freshwater Fish Farming Regulations of 1983 and the *Resource Management Act* of 1991. The regulations cover both freshwater and marine species farmed on land. The only species that may be raised are ones that are approved for farming under this regulation.

2.7.3 Recent developments and current issues

Aquaculture reform

In December 2001, the Minister of Fisheries presented a Resource Management Amendment Bill, which established a two-year moratorium on the issuance of aquaculture permits. The moratorium was put in place to avoid a further speculative rush for space to be used for aquaculture, as there was, at that time, an overabundance of applications for aquaculture operations, which resulted in an increase in treatment costs. This overabundance was due to a lack of clear legislation and efficient administrative processes for aquaculture.

The moratorium provided manoeuvring room that the central government needed to bring about ordered change and to put in place legislation that applies major reforms relating to aquaculture. The Minister of Fisheries is leading the reform initiative, in collaboration with the Ministers of Environment, of Conservation and of Maori Affairs (Ministry of Fisheries and Ministry for the Environment, 2000). The reforms will be enacted through another Resource Management (Aquaculture) Amendment Bill. It is expected that the bill will be enacted in March, 2003 with full implementation by March, 2004 when the current moratorium on new aquaculture applications expires.

The purpose of the reform is to enable aquaculture to increase its contribution to the national economy without undermining the fisheries management regime or claims settlements resulting from treaties, while ensuring that adverse effects of aquaculture are properly managed. The reforms will increase the powers of regional councils to manage and control the development of aquaculture by requiring new development to take place within specially designated Aquaculture Management Areas (AMA).

The reforms will enable an integrated approach to be taken to coastal planning, the development of aquaculture, and fisheries management, and remove much of the duplication in the current regulatory regime for aquaculture (Ministry of Fisheries and Ministry for the Environment, 2001). Regional councils will have sole responsibility for managing the adverse effects of aquaculture on the environment. To provide ongoing protection of fisheries interests, including the Crown's obligations to the Maori under the Deed of Settlement, the Ministry of Fisheries will continue to determine whether the establishment of a proposed Aquaculture Management Area may have an undue adverse effect on fishing. The Ministry of Fisheries will also maintain a registry of fish farmers, to impose restrictions in relation to the acquisition and disposal of farmed stock.

However, the plan could be delayed as the Ministry of Fisheries is currently dealing with a claim from the Maori for 20% of the AMA space. (The Maori usually receive 20% of the quota for any new species added to the Fisheries Quota Management System). This is likely to become a political issue and it is not clear how this will affect the reforms and the related schedule.

Vision 2020

In 2001, the industry adopted a vision statement for 2020, which declares that :

> *Aquaculture will maximize job creation and foreign exchange earnings through a planned and sustainable expansion, and that it be the lead in the New Zealand seafood industry, operating under enabling legislation that recognizes the rights of all users of the coastal marine area (NZAC, 2001).*

In the vision, the New Zealand industry estimates that the sector could achieve exports earnings of more than $678 million in 2020. In doing so, the current challenges that need to be addressed are:

- reforming aquaculture legislation, while grandfathering, as acquired rights, all
- existing types of tenures into the reformed regime;
- providing secure property rights for aquaculturists;
- improving coastal planning tools for regional councils;
- putting in place an efficient, fair and equitable aquaculture site allocation
- process;
- streamlining the objectives of all marine legislation; and
- resolving ownership issues with respect to the seabed.

Oceans Policy

In 2000, the Government of New Zealand announced that it was developing an Oceans Policy, which it judged to be needed to address current and anticipated problems with the regimes used to manage the marine environment, in particular:

- the inability to manage the marine environment in a way that is consistent with the physical reality that it presents;
- conflict between specific management regimes for particular activities, including aquaculture;
- and gaps in management regimes (activities for which there is no management regime).

Public consultation on a proposed draft policy is to take place by July 2003.

2.7.4 Major programs and services provided

The information contained in this section is derived primarily from three sources: firstly, from discussions with officers from the New Zealand Ministry of Fisheries, secondly, from the web sites of all the organizations described below and finally, from a series of government publications.

Research & Development

The Foundation for Research, Science and Technology (FRST) invests in research, science and technology on behalf of the New Zealand government to enhance the wealth and well-being of the whole population. It is a public body, with a board of directors appointed by the government. The FRST invests nearly $260 million annually in a wide range of R&D initiatives with economic, environmental and social benefits. Any aquaculture research proposals have to compete with other research areas for government funding.

The FRST funds almost all of the activities of the National Institute of Water and Atmospheric Research (NIWA), which carries out some research into aquaculture. Established in 1992 as one of nine New Zealand Crown Research Institutes (CRIs), NIWA's mission is to provide a solid scientific basis for the sustainable management and development of New Zealand's atmospheric, marine and freshwater systems and associated resources. The NIWA has a staff of approximately 600 and annual revenue of more than $50 million.

The NIWA's National Centre for Fisheries & Aquaculture (NCFA) provides access to NIWA's expertise in fisheries and aquaculture planning, development and research, for instance in support of the regional councils when developing aquaculture management areas (AMAs) on their coastlines. NCFA operates a cool-water aquaculture research facility and a warm-water aquaculture research and development centre.

NIWA's R&D programs cover a range of species, from those that have yet to be commercially successful but have considerable market potential (such as seahorses, kingfish, and sea-sponges), to those that are already farmed successfully but for which production is limited by a poor understanding of key biological processes (for example, salmon and abalone). Other species to be studied include freshwater eels, rock lobster, and brine shrimp.

The Centre of Excellence in Aquaculture and Marine Ecology (CEAME) was set up in 1996 by the University of Canterbury and NIWA. The objectives of CEAME are to promote and enhance excellence in aquaculture and marine ecology research, to attract the best students from New Zealand and other countries, to train students at the postgraduate level by sharing and using the joint expertise of university and NIWA personnel, to attract funding to support student training and research, to provide opportunities for students to do research with NIWA scientists both in established and new programs, and to increase collaborative linkages between NIWA and the university.

Technology New Zealand (TNZ), which is a government agency, aims to help businesses develop and adopt new technology. TNZ offers a broad range of programs to the aquaculture industry, which fall into three categories:

- Provision of Technology Information and Technology Watch (go over) which focus on promoting technical innovation by fostering access for small and medium-sized businesses to technology evaluation services, to new technology and to sources for guidance and assistance with technology-based projects;
- Research and Development Projects and Programmes which has three sub-components:

- Technical Assessment Projects (feasibility) to finance short-term experimental investigations of the technical feasibility of a critical step, within the framework of a development plan. Matching funds are available up to $16, 000.
- Grants for Private Sector Research and Development which funds up to 33% of the costs associated with a business's increased spending on R&D, from a minimum of $6, 500 to a maximum of $65, 000 for small and medium-sized businesses.
- Technology for Business Growth (TGB) which helps companies to promote high value-added, high-margin, technology-based products. Under TBG funding, the company may receive up to 50% of eligible project costs.

- The "Human Resources Development" category has two components: Technology in Industry Fellowships which fosters "immersing" experts within a commercial environment and Enterprise Scholarships, which focus on research into areas that are likely to help advance the knowledge economy of the future and that are relevant to enterprises. Scholarships are funded on a 50/50 basis between government and business.

The Cawthron Institute (CI), which is a private, independent, not-for-profit research centre, has been operating for 82 years. The fundamental purpose of CI is to benefit the nation through the positive outcomes of science and technology. CI covers a wide spectrum: from basic research, to specialist scientific advice for commercial clients, to routine laboratory testing. Its areas of specialty comprise shellfish and seaweed aquaculture, biosecurity issues, marine and freshwater science, and analytical chemistry and microbiology.

Cawthron has become a leading centre for research in New Zealand in shellfish and seaweed aquaculture. Most of the research is funded through contracts with the Foundation for Research, Science and Technology (FRST), from its Public Good Science Fund.

2.8 UNITED KINGDOM (SCOTLAND)

2.8.1 Production, economic impact and industry organization

Aquaculture production in the United Kingdom rose from 93,838 tonnes in 1995 to more than 152,000 tonnes in 2000, an annual growth rate of 10.2% (Table 2.11). Scotland accounted for 90% of that output in 2000, a total of 136,626 tonnes.

The United Kingdom therefore posted growth of 58,646 tonnes in six years. Over the same period, Atlantic salmon farming in Scotland alone grew by 58,637 tonnes, accounting for almost 100% of the total increase for the United Kingdom (FRS, 2002a).

From 1995 to 2000, we find that rainbow trout production in the United Kingdom dropped sharply, from more than 16,000 tonnes to 10,911 tonnes. However, this decline in trout production in the United Kingdom therefore was offset by a virtually matching increase in shellfish production, primarily through growth in blue mussel farms, for which production increased from 5,801 tonnes to 11,107 tonnes.

Table 2.11 United Kingdom aquaculture production, 1995 - 2000

Species	Production (tonnes)					
	1995	1996	1997	1998	1999	2000
Atlantic salmon*	70,322	83,344	99,422	110,917	126,686	128,959
Common mussel**	5,801	8,347	13,127	8,956	9,535	11,107
Rainbow trout***	16,134	16,328	15,950	16,563	17,113	10,911
Pacific oyster	535	553	597	559	232	633
Oysters nie****	268	584	400	146	910	479
Sea trout	345	345	.	.	92	113
Turbot	-	-	-	-	-	107
Queen scallop	46	51	46	147	114	58
European cockle	5	8	20	10	43	43
Great scallop	36	36	27	41	27	41
Japanese clam	17	21	36	31	29	29
European flat oyster	189	144	90	51	11	4
Mozambique tilapia	120	120	.	.	.	.
TOTAL	**93,838**	**109,901**	**129,715**	**137,421**	**154,793**	**152,484**
Scotland						**136,626 (90%)**

Source : FAO Fishstat Database Version 2.3. 2002.

*	100% in Scotland	**	approx. 25% in Scotland
***	approx. 50% in Scotland	****	nie: not included elsewhere

In 2000, 68 companies operating more than 346 marine sites dedicated to salmon farming were registered with the authorities (FRS, 2002a). The proportion of these companies held by Scottish interests is about 15%. This means that more than 85% of Atlantic salmon production in Scotland is owned by large multinationals also present in Norway, Chile and Canada.

In 2000 as well, Scotland's aquaculture sector employed some 2,369 people. More than 70% of salmon production is located in northwestern Scotland and the Shetland Islands. Virtually all these jobs therefore are in remote areas with few job opportunities. It should be noted that productivity in the salmon sector, measured in terms of annual output per job, has been rising, from about 60 t/job in 1995 to almost 100 t/job in 2000 (FRS, 2002a).

This same year, farm gate value of production in the United Kingdom was estimated at $670 million, with salmon accounting for some $641 million or more than 95%. The value of trout and shellfish production was $22.5 million and $6.5 million respectively.

The salmon industry contributed to $360 million to Scottish agro-food exports in 1999, almost 40% of all Scottish exports. In 1999, 30,000 tonnes were exported to France. Other export destinations include the United States, Japan and other European Union countries.

Five main professional organizations oversee production in the United Kingdom:

- the *British Marine Finfish Association* represents saltwater farmers in the United Kingdom;
- the *Scottish Salmon Producers' Organisation* and the *Shetland Salmon Farmers' Association* represent most Scottish salmon producers;
- the *British Trout Association* focuses on development of production of this species throughout the United Kingdom;
- the *Association of Scottish Shellfish Growers* represents Scottish mariculturists with various government and community authorities.

In recent years, the salmon farming industry has established two important tools to support production more effectively:

- The Code of Good Practice for measures to contain farmed fish

  In addition to proposing measures for proper design of freshwater as well as saltwater farming systems to prevent fish escapes, this code proposes an official procedure for notifying authorities in the event of escape and potential measures for recapturing fish (SQS – SSFA, 1999). It should be noted that the producer is legally required to report any escape to SEERAD and must also inform the local *District Salmon Fishery Board* and/or the local *Fishery Trust*. If neither organization is located near a given site, the producer must notify any landowner or salmon fishing operator near these facilities.

- The Code of Good Practice to avoid or minimize the impact of infectious salmon anemia (ISA)

  This code was ratified by the industry in 2000. This voluntary code provides measures to control infectious anemia in terms of vertical (from egg to adult to egg) as well as horizontal transmission (from one site to another). Operations linked to fish processing are also covered by this code (Joint Government/Industry Working Group on ISA, 2000).

The Scottish Quality Salmon (SQS), founded in 1992, is an organization that promotes quality and sustainable development of salmon farming and represents some 65% of Scottish production. One of its greatest successes over this period was to obtain French government authorization to use the Red Label for marketing its product in France. To date, Scotish salmon remains the only example of a foreign organic food product authorized to use this seal that guarantees consumers of superior product quality.

SQS administers a quality certification process that covers all inputs and all production and processing stages for salmon, from food producer to processor. In the United Kingdom, products that meet all these characteristics are sold under the Tartan quality brand.

All Scottish Quality Salmon producers must participate in independent certification programs introduced by *Food Certification Scotland Ltd.* (FCS), in line with stated specifications. This organization is accredited by UKAS, the United Kingdom Accreditation Service. SQS certification programs cover three types of product, smolts (Salmon Smolts), farmed salmon (Scottish Quality Farmed Salmon) and smoked salmon (Smoked Scottish Quality Salmon).

Finally, Scottish Quality Salmon has also contributed to the development of environmental impact control systems designed to help its members comply with the requirements of international standard ISO 14001.

SQS recently launched its new five-year plan which calls for sales growth from $675 million to $1.125 billion by 2007. This entails a doubling of Scottish salmon exports.

SQS funds its activities by levying a tax on each tonne of product sold. Salmon producers pay $33 for each tonne produced the previous year. Salmonid producers and mussel producers also fund SQM activities and these certification organizations. In 2001, the total SQM budget was $2.9 million.

2.8.2 Governance structures

The lead agencies for aquaculture are the Department of Environment, Food and Rural Affairs (DEFRA) for the United Kingdom and the Scottish Executive Environment and Rural Affairs Department (SEERAD) for Scotland.

SEERAD's aims are :

- to help improve the economic performance of Scotland's agriculture, aquaculture, fishing and food industries within the wider context of development, in a sustainable manner, of land, sea and freshwater resources and rural development, while safeguarding the interests of consumers, protecting and enhancing the environment, and ensuring judicious use of public funds; and
- to support government in helping the people of Scotland secure a high quality of life through sensitive stewardship and sustainable development of Scotland's natural resources; in particular, and by ensuring that the natural environment is clean, healthy and safe, ensuring a safe and effective aquatic industry.

The Scottish Executive Environment Protection Agency (SEPA) has a duty to control discharges to surface waters and groundwaters, including tidal waters out to the three-mile limit. SEPA does this by issuing a legally-binding "consent" to discharge under the *Control of Pollution Act of 1974* (SEPA, 1997).

In aquaculture, discharges may be from various installations, such as hatcheries discharging into fresh or salt water, and from cage sites in freshwater lakes and the sea. Each application for consent to discharge is considered on its own merits and SEPA normally requests a range of information from the applicant in order to facilitate the process. This may include site-specific information such as (an extensive study of the--NOT FOUND IN FRENCH VERSION) tidal characteristics, detailed descriptions of animals and plants, and chemical characteristics of the seabed.

Before production may begin, there are a number of other licences that the site operator is required to obtain:

- Development Consent and Lease. The UK Crown Estate includes approximately half of the foreshore and most of the seabed in Scotland. To establish a fish farm, the operator must be granted a development consent and lease for the particular area of seabed. The Crown Estate will review the application, looking at issues such as landscape, and interaction with other users of the seabed. An application for a seabed lease involves the preparation of an environmental statement under the Environmental Impact Assessment (Fish Farming in Marine Waters) Regulations of 1999 (SOAEFD, 1999). Fish farm leases are granted following consultation with a number of bodies, including the Scottish Executive, the Scottish Environment Protection Agency, the Scottish Natural Heritage, the relevant local government and local interest groups as well as the general public. The Crown Estate charges rent for use of the foreshore and seabed. Fish farming rents amount to approximately one per cent of a farm's sales. Shellfish farm rents are directly related to approved levels of equipment (size of the installation) and begin at $275 per annum.

- Works Licence. In addition to a seabed lease, in the Orkney and Shetland islands, fish farmers are also required to obtain a Marine Works Licence. The issues considered in reviewing such applications are similar to those dealt with by the Crown Estate and an application for a works licence is likely to involve the preparation of an environmental statement. In the Northern Isles, the Regional Councils also review applications for seabed leases on behalf of the Crown Estate.

- Navigational consent. This is granted by the Scottish Executive Development Department, usually following the grant of the works licence or seabed lease, because the process of dealing with these licences includes consideration of navigational issues.

2.8.3 Recent developments and current issues

Scotland's Strategic Aquaculture Framework

In 2001, SEERAD announced the process for developing a National Scottish Strategy to map out a sustainable future for the aquaculture industry. According to the Scottish Executive, the key to the new development strategy will be the need to strike the right balance between the environmental impact of aquaculture and its socio-economic benefits.

In establishing this open, transparent and inclusive process, the Scottish Executive recognized the concerns surrounding marine fish farming in Scotland. At the same time, the Executive is also reviewing the regulations governing fish farming to identify gaps and to improve current procedures (Wilson, 2001).

The process will be carried out in three stages:

A. firstly, carrying out a wide-ranging, inclusive consultation about the major issues relating to fish farming (completed in Winter and Spring 2002);
B. secondly, developing a more focused debate around a set of strategic proposals (2002); and
C. finally, drawing up a strategy for the future, based on broad consensus (2003).

A Ministerial Working Group on Aquaculture was created in June, 2002 to develop more focused debate around a set of strategic proposals (SEERAD, 2002). The Working Group is chaired by the Deputy Minister of SEERAD with members drawn mainly from industry (British Marine Finfish Association, Scottish Quality Salmon, Shetland Salmon Farmers' Association, British Trout Association, Association of Scottish Shellfish Growers, UK Agriculture Supply Trades Association, Scottish Retail Consortium, etc.) but also from other authorities within the Scottish Executive and from other UK agencies (Scottish Environment Protection Agency, Scottish Natural Heritage, Crown Estate, Convention of Scottish Local Authorities, Highlands and Islands Enterprise and the British Food Standards Agency (FSA) Scottish Food Advisory Committee and some NGOs (Association of Salmon Fishery Boards, World Wildlife Fund (WWF)-Scotland).

To prepare the way for public discussions and debate, the Scottish Executive requested that the Ministerial Working Group address such issues as :

Scotland has an aquaculture industry:

- what are its costs/benefits and how may they be evaluated in objective terms ?
- where does the balance between economic, social and environmental "needs" lie?

The purpose served by the Scottish aquaculture industry:

- how can it help to meet the growing market demand at a time when catches of other species are declining (how to address the so-called "fish deficit") ?
- how can it help to improve the nation's diet and health?

How may each sector of the industry position itself to compete internationally both for the present and over the longer term (5-10 years):

- how can the industry diversify (its production)?
- how might it otherwise increase its competitiveness ?

If there is a desire to ensure the industry's sustainability, both in economic terms and with respect to the environment:

- what factors (for example, the impact on the stocks of fish used for fishmeal) need to be taken into account?
- what further growth would be compatible with Scotland's aspirations with respect to the environment?
- what level of environmental pollution would be regarded as "acceptable" - can Scotland establish such a measure?
- what level of development can Scottish coastal waters (however they may be defined sustain?
- how might environmental impacts be reduced?

Criteria for locating fish farms:

- should farms be sited further off-shore?
- should they be land-based (*anywhere* in Scotland)?
- should they be otherwise re-located (and if so, when and under what conditions)?

Role of the public sector :

- can it be both regulator and sponsor?
- should it continue to be investor?
- what should the sector's role be?

The role of local government in the regulatory process:

- can/should it be more than regulator?

Areas of the industry to be supported by government research :

- what criteria should be applied in identifying research priorities?
- should there be some external scrutiny of the research proposed/undertaken?
- what should be the role of the Fisheries Research Service in aquaculture-related research?
- should there be jointly-funded industry/government research projects (for example, on new technology, new species)?

2.8.4 Major programs and services provided

The information contained in this section was derived from three main sources: firstly, from discussions with officers of SEERAD's Aquaculture Section; secondly, from the web sites of all the organizations described below; and thirdly, from government documents.

R&D Programs

Fisheries Research Service

The Fisheries Research Services (FRS) is an agency within the Scottish Executive Environment and Rural Affairs Department (SEERAD) that is involved in fisheries but also in marine and freshwater aquaculture. FRS's objectives are :

- to provide scientific advice and information;
- to conduct research, monitoring and surveillance;
- to perform regulatory and enforcement activities;
- to represent the Scottish Executive at national and international meetings;
- to communicate issues and information to all stakeholders; and
- to ensure that the policies and regulatory activities of the government are supported by full and up-to-date knowledge.

The FRS runs an aquaculture R&D program with an annual budget of approximately $1.8 million annually. The work carried out is mostly in support of statutory obligations relating to fish health (see Aquatic Animal Health Section below), but also includes significant amounts for environmental R&D.

The FRS operates two laboratories; the Freshwater Fisheries Laboratory in Pitlochry and the Marine Laboratory in Aberdeen.

Aquaculture LINK

Aquaculture LINK is sponsored by the UK Department of Environment, Food and Rural Affairs (DEFRA), SEERAD and the Natural Environment Research Council (NERC). The total sponsorship committed to the programme by these organizations was in excess of $12 million for a five-year period (1996-2000), which means that with industry's minimum commitment of 50 per cent to the cost of projects, the total investment in aquaculture is approximately $24 million. This represents a considerable strategic, applied investment in the development of the UK's aquaculture sector, and one which, for the first time, is industry-led. In this first phase of the Aquaculture LINK Program, 37 projects were supported (PACEC, 2000).

The aim of the Aquaculture LINK Programme is to support pre-competitive and innovative research in subject areas where there are perceived constraints to the commercial development of aquaculture. A distinctive feature is the inclusion of appropriate demonstration projects whose aim to ensure that technology transfer successfully occurs. This aspect is considered to be essential to ensure that the necessary "pull through" takes place from R&D to industrial take-up.

The priority areas for the program are:

- supporting a program of collaborative research and technology transfer under eight priority themes aimed at assisting the development of aquaculture industry in the UK;
- collaboration with industry, and making use of the expertise within government departments having a scientific and technology-related mandate, and in the universities with a view to solving problems facing the aquaculture sector; and
- promoting transfer of technology to the UK aquaculture industry.

The eight inter-related themes identified as key areas for research are:

- Investigation of New Species: includes research into the technical viability of breeding and rearing new species;
- Species Under Development: for those species identified as having potential for cultivation but for which additional research and development is required before they are likely to be taken up by industry;
- Established Species: further research to improve yields;
- Diseases: research on diseases that have proven to be a major constraint to growth of the industry;
- Fish Processing: to help reduce waste while increasing value-added processing to enhance profits;
- Economics and the Market: assessment of the market potential and the economics of production of any aquaculture species, which takes into account all eight themes, as well as the financial and economic aspects of each proposal;
- Demonstration projects: projects that play an important part in fully evaluating the performance of new technology or production processes under real-world operating conditions; and
- research into the Environmental Impacts of aquaculture, to ensure that all proposed development proposals are sustainable and acceptable.

Centre For the Environment, Fisheries and Aquaculture Sciences (CEFAS)

CEFAS is an agency of the UK Government's Department for Environment, Food and Rural Affairs (DEFRA). CEFAS employs over 550 staff at five sites around the UK.

CEFAS is a scientific research and advisory centre for fisheries management and environmental protection. It provides contract research, consulting, and training in fisheries science and management, marine environmental protection, aquaculture, fish and shellfish disease, and hygiene for a large number of public and private sector clients.

As an example of how it operates, CEFAS has developed pheromones which trigger feeding behaviour in fish. This technology can be applied to the aquaculture industry to induce farmed fish to eat a more environmentally-friendly diet, and, consequently, make the industry more sustainable.

Crown Estate Fish Farming Research Program

The Crown Estate has supported aquaculture research for many years. Since 1987, it has provided more than $4.4 million for a variety of projects.

In 2001, the Crown Estate provided a new budget totalling $1.44 million over a three-year period for research to help the Scottish fish farming industry achieve its environmental goals. The Fish Farming Research Committee, which represents aquaculture and environmental interests, was established to provide expert recommendations to the Crown Estate on how the money should be allocated. The committee comprises representatives from the Crown Estate, Scottish Environment Protection Agency (SEPA), Scottish Natural Heritage, Association of Salmon Fisheries Boards, SEERAD, Fisheries Research Service, Scottish Quality Salmon, Shetland Salmon Farmers' Association, British Marine Finfish Association, the Association of Scottish Shellfish Growers and the Shetland Shellfish Growers' Association.

In 2002, the first grants were allocated to various research projects, covering such topics as :

- host odour traps for sea lice;
- health of wild salmon and sea trout;
- biological impact of fish farm nitrogen waste;
- study into the aquaculture carrying capacity of sea lakes and other coastal waters;
- evaluation of automatic feeding systems to promote sustainable and environmentally-sensitive cultivation of Atlantic cod;
- development of new treatments to protect fish against Infectious Pancreatic Necrosis;
- funding of course costs for two M.Sc. studentships for one year;
- establishment of sea bed sampling (benthic) analysis service; and
- halibut broodstock nutrition.

Farm Insurance

There is no publicly-funded farm insurance program that provides a protection to aquaculturists against various risks related to natural hazards (storms, abnormal tides, biotoxins, biological invasions, predators, pollution, etc.) in Scotland. Farms obtain commercial insurance to cover some of these risks in accordance with their needs. One of main companies supplying such niche market insurance is Sunderland Marine Mutual Insurance.

Aquaculture Food Safety Program

The United Kingdom follows the EU regulations regarding food quality standards and the licensing process for therapeutants and pesticides.

The British Food Standards Agency (FSA) is an independent body created in April 2000 by an act passed by Parliament. Its mission is to protect public health, as well as the interests of consumers in food-related areas. It should be noted that FSA set specific targets in its 2001-2006 strategic plan, in particular that of a 20% reduction in food-related diseases, through improvement of food safety at all stages of the food chain.

Although FSA is a government agency, it operates at arm's length of the UK government because it does not report to a specific ministry and remains free to publish any recommendation that it may make. The Agency is headed by a board of directors appointed to act in the public interest and not in the interest of specific sectors. FSA is accountable to Parliament, but also to decentralized administrations in Scotland (Scottish Executive), Wales and Northern Ireland for all FSA activities within their territory.

FSA closely monitors toxins present in shellfish. There currently is no financial support program, especially for a product quality monitoring program at the farm gate (such as On Farm HACCP).

Industry Development

The Scottish Executive does not provide any aquaculture-specific Investment Fund or Capital Venture Fund. However, industry can make an application to the aquaculture assistance program under the European Union's Financial Instrument for Fisheries Guidance (SEERAD, 2000) (see Section 2.9.4). Moreover, the Highlands and Islands Enterprise (Scottish Executive) network does provide various forms of assistance to businesses located in its territory.

Marketing and Trade

There are no specific programs that support marketing of fish, such as generic branding of Scottish products, or providing market intelligence to industrial and government clients. However, organizations such as Seafood Scotland do support Scottish seafood companies seeking export opportunities. In addition, as is the case for all UK businesses, aquaculture companies have access to the resources of UK Trade Partners (the joint Foreign and Commonwealth Office/Department of Trade and Commerce export trade operation) and, in Scotland, Scottish Development International (a joint Scottish Executive/Scottish Enterprise operation).

Infrastructure

There is no special funding program put in place to properly maintain port infrastructures that are of strategic importance for further development of aquaculture. However, the European Union's Financial Instrument for Fishery Guidance (FIFG) Structural Funds arrangements provide for an assistance program for port infrastructure.

Aquatic Animal Health

The United Kingdom applies the EU Fish Health Regime, which was established to limit the spread of the most serious diseases in Europe (see Section 2.9.4 for a comprehensive description of the Regime).

The Fish Health Inspectorate within CEFAS fulfils the responsibilities relating to England and Wales arising from UK policies adopted under the EU regime. In Scotland, the Fisheries Research Services (FRS) of SEERAD is responsible for fish health control.

In relation to fish health, it is worth noting that the Scottish industry does contribute financially to the FRS's statutory fish health inspection regime, the cost of which amounts to approximately $2.4 million annually.

The current policy of the Scottish Executive is not to pay compensation for losses arising from statutory fish disease controls as there is no legal obligation to do so, under either domestic or European legislation. However, the Scottish Court of Session has consulted the European Court of Justice (ECJ) on two legal challenges to this policy. The ECJ has yet to respond formally to the Scottish Executive on the matter. This issue will be addressed as part of the current development of a strategic framework for aquaculture.

Following the outbreak of Infectious Salmon Anaemia (ISA) in Scotland in May, 1998, the ISA Re-Start Scheme was established by SEERAD in the autumn of 1999. A total of $21 million has been made available over three fiscal years (1999-2002). The Scheme is administered on SEERAD's behalf by Highlands and Islands Enterprise (HIE).

The objective of the Scheme is to help maintain employment and business activity in fish and shellfish farming businesses in the Highlands and Islands that were adversely affected by ISA. Applicants have to adhere to the SEERAD/industry *Code of Practice to avoid and minimise the impact of ISA*, and meet a number of other standard conditions of HIE's assistance schemes (SEERAD, 2001). According to SEERAD and HIE officers, the Re-Start Scheme is not a compensation scheme as the normal assessment procedures for discretionary assistance are applied to requests for assistance. The maximum level of a grant is for 50% of all costs related to enabling the business to become re-established at its previous level of sales.

From 1999 to the end of 2001, 26 companies received grants totalling $11 million.

For several years, the Scottish Executive has undertaken early vaccine development work which, in certain cases, has then been picked up and commercialized by the pharmaceutical sector; however, most therapeutants are pioneered exclusively by the private sector. Nevertheless, there is no funding program specifically directed towards companies interested in developing a pharmaceutical product to be used only in aquaculture.

2.9 EUROPEAN UNION

2.9.1 Production, economic impact and industry organization

With aquaculture production of almost 1.3 million tonnes in 2000, the European Union, if considered as a national entity, is the world's fourth largest producer after China, India and Japan. Table 2.12 details the annual production of the 15 European Union member countries from 1995 - 2000.

Table 2.12 Aquaculture production of European Union member countries, 1995 - 2000

Member countries	Production (tonnes)						Aquaculture / total production
	1995	1996	1997	1998	1999	2000	1999
1. Spain	223,965	231,633	239,136	315,477	321,145	312,171	**14.7 %**
2. France	280,786	285,526	287,243	267,855	264,850	267,767	**46.6 %**
3. Italy	214,725	189,373	195,719	208,625	210,368	216,525	**30.3 %**
4. United Kingdom	93,838	109,901	129,715	137,421	154,800	152,485	**39.3 %**
5. Greece	32,644	39,852	48 838	59,926	79,474	79,879	**56.2 %**
6. Netherlands	83,938	99,871	98 ,210	120,094	108,785	75,339	**20.2 %**
7. Germany	58,096	75,237	59,433	67,020	73,567	59,891	**45.2 %**
8. Ireland	27,366	34,925	36,854	42,375	43,856	51,247	**30.3 %**
9. Denmark	44,730	41,924	39,697	42,368	42,670	43,609	**24.2 %**
10. Finland	17,345	17,659	16,426	16,024	15,449	15,400	**86.2 %**
11. Portugal	4,981	5,364	7,185	7,536	6,268	7,538	**14.7 %**
12. Sweden	7,573	8,267	6,709	5,504	6,035	4,834	**14.4 %**
13. Austria	2,921	2,952	3,021	2,912	3,070	2,847	**87.7 %**
14. Belgium	846	946	846	846	1,597	1,641	**4.7 %**
15. Luxemburg	--	--	--	--	--	--	**--**
TOTAL	**1,093,754**	**1,143,430**	**1,169,032**	**1,293,983**	**1,331,934**	**1,291,173**	**30.8 %**

Source : FAO Fishstat Database Version 2.3. 2002.

In terms of volume, Spain ranks first with more than 312,000 tonnes, followed by France, Italy, the United Kingdom and Greece. These five countries alone accounted in 2000 for more than 77% of European Community production.

The average annual growth rate of European production between 1995 and 2000 was approximately 3.5%. This rate is fairly low compared with other regions of the world, but is explained in part by the poor performance of France, where production dropped an average of 1% during the period. By contrast, Spain, the United Kingdom and Greece posted strong growth with respective rates of 7.0%, 10% and 19.5%.

Table 2.13 presents the 24 leading species produced by the member states. These 24 species totalled more than 99% of production in 2000. This list is heavily dominated by mussels (Spain and France), which account for more than one third of production, followed by rainbow trout (France, Italy, Denmark), Atlantic salmon (United Kingdom) and Pacific oysters (France).

Table 2.13 ***The 24 leading aquaculture species produced by European Union member countries, 1995 - 2000***

Species	Production (tonne)						
	1995	1996	1997	1998	1999	2000	% en 2000
1. Mussel	347,700	395,752	387,818	485,077	479,139	434,135	33,6%
2. Rainbow trout	235,173	236,729	237,538	232,074	222,234	222,466	17,2%
3. Atlantic salmon	83,748	98,920	116,926	127,346	146,139	147,343	11,4%
4. Pacific oyster	149,027	155,958	153,048	143,824	145,307	140,283	10,9%
5. Mediterranean mussel	109,844	102,194	104,049	115,235	119,812	113,772	8,8%
6. Japanese clam	60,120	40,531	40,376	49,894	51,976	55,858	4,3%
7. Gilthead seabream	16,694	22,272	27,958	35,105	47,199	55,702	4,3%
8. European sea bass	16,521	18,479	22,933	28,870	36,307	40,285	3,1%
9. Common carp	20,747	18,735	19,226	17,833	17,849	17,833	1,4%
10. European eel	6,831	8,523	8,628	9,712	10,469	10,561	0,8%
11. European flat oyster	5,550	5,654	5,382	5,616	6,143	5,876	0,5%
12. Turbot	2,977	2,571	3,001	3,087	4,103	4,785	0,4%
13. European cross clam	7,214	2,765	4,719	4,921	3,915	4,777	0,4%
14. European cockle	7,402	5,157	5,097	4,361	5,320	4,678	0,4%
15. Tuna type fish nie*	15	77		1,959	3,346	3,682	0,3%
16. Striped mullet	3,505	3,602	3,380	3,524	3,430	3,513	0,3%
17. Gracilaria seaweeds	5,000	5,000	5,000	3,000	3,000	3,000	0,2%
18. North African catfish	1,019	1,200	1,206	1,491	1,744	3,000	0,2%
19. Sea trout	2,498	2,884	2,575	2,320	3,044	2,813	0,2%
20. Oysters nie*	1,601	1,724	1,637	2,694	4,079	2,515	0,2%
21. Roach	2,500	2,500	2,700	2,500	3,000	2,500	0,2%
22. Blue clam	<0.5	1,929	3,106	2,408	2,330	1,934	0,1%
23. Saltwater fish nie*	68	325	595	1286	2,042	1,511	0,1%
24. Tench	163	860	1,621	1,374	1,736	1,372	0,1%
Total 24 species	**1,085,917**	**1,134,341**	**1,158 519**	**1,285,511**	**1,323,663**	**1,284,194**	**99%**
Total European Union	**1,093,754**	**1,143 430**	**1,169,032**	**1,293,983**	**1,331,934**	**1,291,173**	**100%**

Source : FAO Fishstat Database Version 2.3. 2002.

* nie: not included elsewhere

The two species with the strongest growth are gilthead seabream and European sea bass, with annual growth rates of 27% and 19.5% respectively. These species are produced primarily in Greece and Italy.

The CEC estimates the total number of direct full-time or seasonal jobs in the aquaculture sector in 1999 at 80,000. For that same year, the farm gate value of production was $3.9 billion.

The national economic importance of aquaculture can be measured in part by the proportion of total fish production (capture and aquaculture) accounted for by aquaculture. This proportion varies greatly from one member state to another, ranging from 14.4% in Sweden to 86.2% in Finland (Table 2.12). For the EC as a whole, the ratio is 30.8% (CEC, 2001a).

The main industry organization within the EU is the *Federation of European Aquaculture Producers* (FEAP). This international organization is composed of the national aquaculture associations of European countries as membership in the Federation is restricted to these, however, this includes non-EU member country such as Norway. In certain cases, countries have national associations for specific species (e.g. the United Kingdom has national associations relating to culture of trout, salmon, etc.) while others (for example, Italy and France) have national associations that cover all species.

The basic aims of the FEAP are:

- to develop and establish a common perspective on questions relating to the production and marketing of aquaculture species that are reared professionally;
- to make known to the appropriate authorities the common perspectives mentioned above.

FEAP adopted its own Code of Conduct for European Aquaculture. The code was developed by experts and producers in consultation with a wide range of international bodies and was unanimously approved by the FEAP Assembly in 2000. The primary goal of the code of conduct is to promote the responsible development and management of a viable European aquaculture sector in order to assure a high standard of food production while respecting environmental considerations and consumer demands. Another important FEAP initiative is *Aquamedia*, which is a web site having as its focus the publication of accurate and up-to-date information about aquaculture.

2.9.2 Governance structures

To manage fisheries and aquaculture in the best interests of communities of fishers, aquaculturists and consumers, the European Union established a *Common Fisheries Policy*. This community policy entails four main areas of intervention for concerted action:

- Conservation: regulation of the volume of fish caught at sea;
- Structural aid – financial support for the fisheries and aquaculture sectors to adapt their facilities and organizations to the requirements resulting from fishing and production conditions and to the market;
- Markets: joint organization of markets for products and adjustment of supply and demand to benefit producers as well as consumers;
- Foreign relations: fisheries agreements negotiated internationally to establish joint conservation measures applicable to fishing on the high seas.

Joint organization of markets for fisheries and aquaculture products has been made possible by the dismantling of tariff barriers and other measures likely to obstruct movement of products between member states and by the definition of joint rules to govern the market for fish (CEC, 2002b). This joint organization now has four factors that ensure its success:

- joint marketing standards for fresh products (quality, class, preparation and labelling of EU and imported fisheries and aquaculture products);
- producer organizations, volunteer associations of fishers formed to facilitate market stabilization and protect fishers from sudden swings in demand;
- a price support mechanism that sets minimum prices below which fisheries products may not be sold; producer organizations can obtain financial assistance if they must remove fisheries products from the market, store them for later use, or process them; and
- rules governing trade with third countries, to strike a balance between market needs and the interests of EU fishers, but also to ensure compliance with competition regulations.

In terms of direct intervention, the European Parliament (EP) and the Commission of European Communities (CEC) in recent decades have adopted a series of acts, regulations, decrees, notices, policies and directives in a large number of sectors involving all aspects of relations between member states. In particular, the EP and CEC have legislated on and structured the aquaculture sector on issues such as:

- food additives;
- animal health in general and food from farmed organisms in particular;
- the environment ;
- packaging and labelling;
- markets and marketing;
- research;
- product safety and facility hygiene (including all standards governing exports and imports of live bivalves and other live or finished aquatic products);
- structural assistance put in place, of which the most important for aquaculture is definitely the *Fisheries Guidance Financial Instrument* (FGFI); and
- other topics, including shipping of animals, standards for aquaculture statistics in member countries, the Common Policy control system, etc.

Section 2.9.4 provides details on the nature of FGFI intervention and the methods used.

2.9.3 Recent developments and current issues

Reform of the Common Fisheries Policy

EU legislation that is in effect called for a review of the common fisheries policy during 2002. In March 2001, the Commission published its report on the status of EU fisheries as required by the legislation in force, as well as a *Green Paper on the Future of the Common Fisheries Policy (CFP)*, reviewing the weaknesses of the CFP and the challenges it must meet. It also presented a number of options for reform. The key objective of this reform is to ensure sustainable development of the fisheries and aquaculture sectors:

- through responsible and sustainable fishing and aquaculture activities that contribute to sound, healthy marine ecosystems;
- through a focus on the economic viability and competitiveness of the fisheries and aquaculture sector, to the benefit of consumers; and
- through achievement of a reasonable standard of living for people dependent on fisheries and aquaculture activities.

For aquaculture, the European context determining the sector's development has been dominated over the past decade by growing environmental constraints and concerns related to protection of public health. This pressure from environmental groups and the general public has been favourably received by national governments and the European Commission. The Commission, while recognizing that aquaculture makes an important contribution to the supply of fish and provides substitute jobs in many regions dependent on the fishery, which is often in decline, stipulated in the *Green Paper* that aquaculture must effectively meet the challenges arising from requirements related to the environment and health protection (CEC, 2001b).

In its timeline for implementing reform, the CEC acknowledged its role to provide the best conditions possible for sustainable development of European aquaculture (CEC, 2002a). To this end, the CEC decided to focus on three areas of intervention: research, establishing a suitable environment for development, and establishing common health standards.

According to CEC, aquaculture faces three main challenges:

1. market price instability typical of young, rapidly growing agrofood sectors;
2. the steadily growing negative perception that aquaculture products are contaminated by toxic chemicals, although this is rarely the case;
3. the major problem of public opinion on aquaculture in some areas due to its negative impact on the environment.

Based on these findings, the CEC established a strategy for intervention with the objective of ensuring a supply of safe products for consumers, promotion of activities that respect the environment, and job creation, especially in regions dependent on traditional fishing (CEC, 2002d).

To implement the strategy based on a 4% annual production growth target, the CEC specifically intends in coming years to introduce measures and programs designed to:

- Promote increased aquaculture production, specifically by recentring its priorities related to public assistance granted through FGFI, and by creating a set of common standards to recognize and structure the development of *organic aquaculture*. Current EU legislation on organic agriculture does not include specific provisions on aquaculture;
- Manage access to farming sites more effectively by planning to include future aquaculture developments in integrated coastal zone management plans (GIZC) consistent with official ratification of these principles of integrated management by the European Parliament in 2002, and by facilitating development of technoloogy required for off-shore farming;
- Develop markets specifically by promoting use of the seal of quality and by enhancing the sector's image in general;
- Place emphasis on training and recognize the role of aquaculture in regional development and land use;
- Promote greater use of self-monitoring systems such as codes of good practice and especially implementation of the *EMAS* (Environmental Management and Audit System) system, the official EU system for environmental management and impact audits (comparable to ISO 14 001 and other standards), which is widely used in agriculture;

- Guarantee the safety of aquaculture products by recasting EU legislation on food safety (completed in 2002), aquatic animal health and veterinary medicine in light of recent changes in production, technology and management systems as well as new diagnostic techniques;
- Implement a new directive on well-being, biological needs and health of farmed fish to improve the public perception of intensive aquaculture and in some cases reduce the effects on the environment;
- Manage the environmental impact of aquaculture more effectively, specifically through waste abatement, management of demand for wild fish for grow-out, development of instruments to reduce the impact of escapes, exotic species and GMOs, and recognition and reinforcement of the positive effects of extensive cultivation and restocking; and
- Extend options for funding research and development in technology and set research priorities.

When this strategy was tabled on September 19, 2002, the Commissioner of Fisheries, Mr. Fischler, estimated that implementation of the strategy would create 8,000 to 10,000 new jobs in coastal and rural areas of Europe over the five-year period, 2003 to 2008 (CEC, 2002e).

2.9.4 Programs and Services Offered by the European Union

The Commission of European Communities (CEC) Financial Aid Program: Fisheries Guidance Financial Instrument (FGFI)

A) FGFI Version 2000-2006

Since 1994, the financial assistance available to the fisheries and aquaculture sector has operated in the context of Community Structural Funds. The ***Fisheries Guidance Financial Instrument*** **(FGFI)** is the key instrument for EU assistance to the sector. An initial version of FGFI was in place from 1994 to 1999, when it was recast for a second version of the program, in effect from 2000 to 2006. A notable difference in the new version is that since January 1, 2000, assistance is now available for fisheries in domestic waters.

In aquaculture, the CEC has two assistance measures focusing primarily on increased production capacity (new production units and/or extension of existing production units) and secondly, modernization of existing aquaculture units, but with no increase in production capacity. Specifically, financial assistance may be granted for investment related to production and management, to improving safety conditions and product quality, or to reducing impacts on the environment, or for work to install or upgrade water supply systems in aquaculture operations (CEC, 2002c).

The type of intervention and level of assistance available are primarily determined by economic criteria defining geographic regions of the European Union. For example, regions with a development delay (per capita Gross Domestic Product less than 75% of the EU average) are a priority. These coastal regions and fisheries and aquaculture activities located in these regions not only may obtain FGFI support but also may access the European Regional Development Fund (ERDF) and the European Social Fund (ESF) for measures such as training. These regions represent about 22% of the population of the European Union (Category 1).

The second category covers regions faced with economic and social reconversion, including regions dependent on fishing, that are in difficulty. The regions involved will be selected by member states based on two criteria: the sector's share of total employment; and the number of jobs lost in the sector through restructuring. Regions falling into this category represent about 18% of the EU's population (Category 2). The third category covers all other regions (Category 3).

Table 2.15 shows the levels of financial participation by the Community, governments and the private sector, based on location of a given private project.

Table 2.15 ***Participation rate for the European Community, governments and the private sector in aquaculture projects funded by FGFI, based on location***

Region	Participants	Participation rate
Category 1	European Community Government (national, regional or local) Private sector	Maximum 35% Minimum 5% Minimum 40%
Category 2	European Community Government (national, regional or local) Private sector	Maximum 50% Minimum 5% Minimum 25%
Category 3	European Community Government (national, regional or local) Private sector	Maximum 15% Minimum 5% Minimum 60%

Table 2.14 presents the nine areas of FGFI intervention. The information in this table shows that these areas cover a very broad spectrum, from restructuring fisheries effort to promotional activities in markets, as well as aquaculture development, processing and training.
It should be noted that consistent with EU legislation, financial aid for intensive fish farming projects is approved only if an environmental impact assessment has been conducted.

Decisions on FGFI assistance are made in two stages:

1. member states submit proposals for programs to the Commission for structural assistance in the fisheries sector, in which they describe the aid strategy and related priorities, and an application for funding, in the form of a consistent set of multi-year measures;
2. based on these projects, the Commission negotiates programs with member states, then approves them once agreement has been reached with the member states.

FGFI aid therefore may be granted to private developers submitting a project to their local, regional or even national authorities, but also to these developers for major projects negotiated in advance with the CEC. For the period from 2000 to 2006, EU participation may reach 75% of the total cost of an infrastructure project in less developed regions and 50% in other regions.

Table 2.14 Description of areas for assistance and measures under the European Union's Fisheries Guidance Financial Instrument (FGFI)

AREAS FOR ASSISTANCE	MEASURES
1. ADJUSTMENT OF FISHING EFFORTS	1. Demolition 2. Export/Other assignment 3. Joint venture 4. Temporary association of businesses
2. RENEWAL AND MODERNIZATION OF FISHING FLEET	1. Construction of new ships 2. Repowering, improvement of occupational safety conditions (ships), improvement of product hygiene and safety conditions, new, more selective fishing techniques, installation of equipment to monitor fishing activities on board ships, other investment in existing ships
3. AQUACULTURE	1. Expanded aquaculture capacities (new production units and/or extension of existing production units) 2. Modernization of existing aquaculture units, but with no increase in production capacity
4. PROTECTED MARINE ZONES	1. Development of protected marine zones
5. FISHING PORT FACILITIES	1. Construction of new facilities/extension of existing facilities 2. Modernization of existing facilities, but with no increase in physical capacity
6. PRODUCT PROCESSING – MARKETING	1. Increase in processing capacity (new production units and/or extension of existing production units) 2. Modernization of existing processing units, but with no increase in production capacity 3. Modernization of existing marketing facilities 4. Construction of new marketing facilities
7. PROMOTION	1. Promotional campaigns 2. Participation in trade shows 3. Market studies and consumer surveys 4. Consulting, sales aids and other services available to wholesalers and retailers 5. Quality certification operations and product labelling
8. OTHER MEASURES	1. Studies, pilot projects, technical assistance and other specific measures 2. Actions implemented by professionals 3. Temporary stoppage of fishing activities 4. Specific compensation measures for fishers (ad hoc Council decisions) 5. Miscellaneous
9. SOCIO-ECONOMIC MEASURES	1. Preretirement 2. Individual buy-out bonus

Expenditures programmed as part of FGFI for 2000-2006 amount to almost $5.75 billion or some $960 million a year. Forecast expenditures for the entire period must be spread over the various areas for which assistance and other measures are provided, and divided among the many players: European Union, member states, regional or local governments, and private recipients. Program management authorities regularly adjust programming throughout the assistance period in responses to changes in the situation, progress achieved in various areas, as well as new needs.

B) FGFI 1st Version 1994-1999

Programmed expenditures as part of FGFI for 1994-1999 were about $4.46 billion, or $740 million a year. During this period, fishing effort adjustment absorbed more than 27% of the FGFI budget envelope while funds allocated to expanding production or modernizing aquaculture facilities totalled more than $357 million or almost $60 million a year. These amounts obviously involve only production capacity and enhanced competitiveness. Measures for processing, product promotion and fishing ports for example could also be directly linked to aquaculture activities. However, the data currently available from CEC do not provide this level of detail on FGFI assistance.

Table 2.16 provides details on FGFI assistance in the aquaculture sector in all European Union member states from 1994 to 1999. These data reveal the following:

- FGFI provided funding for some 3,640 aquaculture projects with a total value of almost 500 million euros ($792 million). Public aid for these projects covered about 48.5% (225 million euros or $357 million) of the cost, 36.5% from the Community and 12% from member states (56 million euros or $89 million). The private sector participation rate for all projects therefore exceeded 50%.

- Almost two thirds of these projects involved modernization of aquaculture facilities while slightly more than one third involved expansion of production capacity.

- For the Union as a whole, all FGFI public interventions in aquaculture amounted to an average investment of 425 euros ($674) for each new tonne of product between 1994 and 1999. For projects to enhance productivity, public investment amounted to 76 euros ($120) for each tonne of average annual output for the same period.

- Since the average value of a tonne of aquaculture products in 1999 was 1,791 euros ($2,839), the average subsidy rate was 24% and 4% respectively for an expanded production project or for enhanced competitiveness.

- The average investment was slightly more than 100,000 euros ($158,000) for a project to expand production and almost 40,000 euros ($63,000) for other projects.

- The breakdown of aid from the Community heavily favoured Spain with almost 30% of the total budget (see Figure 2.7). It was followed by Greece (16%), Italy (13%), France (9%) and the United Kingdom (6%). These five countries totalled about 73% of FGFI aid. In 1999, their aquaculture production totalled more than 77% of European output.

Table 2.16 ***Details of public assistance by member states and the European Union for aquaculture, 1994-1999***

Country	Aquaculture measure	Number of projects	Total cost (M Euros)	Govt. aid (M Euros)	Govt. aid (%)	EU aid (M Euros)	EU aid (%)	Total public aid (M Euros)	Total public aid for Aquaculture (%)	Production (tonnes)	Public aid/ tonne of output (Euros)	Public aid / project (Euros)
Spain 30%*	Expand prod.	57	33.08	2.87	8.7%	15.13	45.7%	18.00	54.4%	143,205**	126	315,789
	Enhance compet.	975	75.98	8.81	1..6%	36.35	47.8%	45.16	59.4%	266,271***	180	46,318
	Total	1,032	109.06	11.68	10.7%	51.48	47.2%	63.16	57.9%			61,202
France 9%	Expand prod.	422	34.87	5.94	17.0%	8.21	23.5%	14.15	40.6%	-16,104	N/a	33,531
	Enhance compet.	635	35.56	6.17	17.4%	7.11	20.0%	13.28	37.3%	277,869	48	20,913
	Total	1,057	70.43	12.11	17.2%	15.32	21.8%	27.43	38.9%			25,951
Italy 13%	Expand prod.	99	50.71	6.66	13.1%	19.69	38.8%	26.35	52.0%	33,947	776	266,162
	Enhance compet.	5	3.44	0.34	9.9%	1.66	48.3%	2.00	58.1%	199,205	10	400,000
	Total	104	54.15	7.00	12.9%	21.35	39.4%	28.35	52.4%			272,596
United Kingdom 6%	Expand prod.	68	16.88	2.50	14.8%	7.07	41.9%	9.57	56.7%	69,099	138	140,735
	Enhance compet.	33	7.05	1.21	17.2%	2.99	42.4%	4.20	59.6%	118,563	35	127,273
	Total	101	23.93	3.71	15.5%	10.06	42.0%	13.77	57.5%			136,337
Greece 16%	Expand prod.	153	67.53	7.70	11.4%	23.26	34.4%	30.96	45.8%	46,292	669	202,353
	Enhance compet.	39	12.39	1.40	11.3%	4.21	34.0%	5.61	45.3%	48,986	115	143,846
	Total	192	79.92	9.10	11.4%	27.47	34.4%	36.57	45.8%			190,469
Netherlands 1%	Expand prod.	4	3.00	0.41	13.7%	1.00	33.3%	1.41	47.0%	-594	N/a	352,500
	Enhance compet.	0	0.00	0.00	n/a	0.00	n/a	0.00	n/a	103,380	--	n/a
	Total	4	3.00	0.41	13.7%	1.00	33.3%	1.41	47.0%			352,500
Germany 5%	Expand prod.	105	13.90	1.12	8.1%	4.78	34.4%	5.90	42.4%	31,215	189	56,190
	Enhance compet.	146	10.34	0.95	9.2%	3.31	32.0%	4.26	41.2%	62,618	68	29,178
	Total	251	24.24	2.07	8.5%	8.09	33.4%	10.16	41.9%			40,478
Ireland 8%	Expand prod.	84	26.94	1.76	6.5%	9.71	36.0%	11.47	42.6%	15,241	753	136,548
	Enhance compet.	28	8.28	0.48	5.8%	3.27	39.5%	3.75	45.3%	35,665	105	133,929
	Total	112	35.22	2.24	6.4%	12.98	36.9%	15.22	43.2%			135,893
Denmark 3%	Expand prod.	38	17.02	0.86	5.1%	4.26	25.0%	5.12	30.1%	-222	N/a	134,737
	Enhance compet.	28	4.70	0.24	5.1%	1.17	24.9%	1.41	30.0%	42,380	171	50,357
	Total	66	21.72	1.10	5.1%	5.43	25.0%	6.53	30.1%			98,939

* This percentage indicates the proportion of Community aid dedicated to aquaculture and received by the government, 1994-1999.

** Increase in production between 1994 and 1999 in tonnes. *** Average annual production, 1994-1999.

Table 2.16 Details of public assistance by member states and the European Union for aquaculture, 1994-1999 (cont.)

Country	Aquaculture measure	Number of projects	Total cost (M Euros)	Govt. aid (M Euros)	Govt. aid (%)	EU aid (M Euros)	EU aid (%)	Total public aid (M Euros)	Total public aid for aquaculture (%)	Production (tonnes)	Public aid / tonne of output (Euros)	Public aid / project (Euros)
Finland 2%*	Expand prod.	103	3.24	0.50	15.4%	0.85	26.2%	1.35	41.7%	-1,233**	N/a	13,107
	Enhance compet.	137	7.09	1.08	15.2%	1.75	24.7%	2.83	39.9%	16,598***	171	20,657
	Total	240	10.33	1.58	15.3%	2.60	25.2%	4.18	40.5%			17,417
Portugal 5%	Expand prod.	18	7.90	1.54	19.5%	5.20	65.8%	6.74	85.3%	-293	N/a	374,444
	Enhance compet.	16	2.82	0.50	17.7%	2.51	89.0%	3.01	106.7%	6,616	477	188,125
	Total	34	10.72	2.04	19.0%	7.71	71.9%	9.75	91.0%			286,765
Sweden 2%	Expand prod.	78	6.10	0.60	9.8%	2.16	35.4%	2.76	45.2%	-1,397	N/a	35,385
	Enhance compet.	113	5.20	0.47	9.0%	1.87	36.0%	2.34	45.0%	6,920	338	20,708
	Total	191	11.30	1.07	9.5%	4.03	35.7%	5.10	45.1%			26,702
Austria 1%	Expand prod.	112	4.70	1.10	23.4%	0.58	12.3%	1.68	35.7%	-36	N/a	15,000
	Enhance compet.	136	4.71	1.09	23.1%	0.51	10.8%	1.60	34.0%	2,997	534	11,765
	Total	248	9.41	2.19	23.3%	1.09	11.6%	3.28	34.9%			13,226
Belgium 0,2%	Expand prod.	3	0.94	0.02	1.6%	0.33	35.1%	0.35	36.7%	751	459	115,000
	Enhance compet.	4	0.23	0.03	13.0%	0.05	21.7%	0.08	34.8%	988	81	20,000
	Total	7	1.17	0.05	3.8%	0.38	32.5%	0.43	36.3%			60,714
Luxemburg 0,05%	Expand prod.	1	0.26	0.03	11.5%	0.08	30.8%	0.11	42.3%	0	n/a	110,000
	Enhance compet.	0	0.00	0.00	n/a	0.00	n/a	0.00	n/a	0	N/a	n/a
	Total	1	0.26	0.03	11.5%	0.08	30.8%	0.11	42.3%			110,000
Grand Total 100 %	Expand prod.	**1,345**	**287.07**	**33.61**	**11.7%**	**102.31**	**35.6%**	**135.92**	**47.3%**	**319,871**	**425**	**101,052**
	Enhance compet.	**2,295**	**177.79**	**22.77**	**12.8%**	**66.76**	**37.5%**	**89.53**	**50.4%**	**1 174,033**	**76**	**39,011**
	Total	**3,640**	**464.86**	**56.38**	**12.1%**	**169.07**	**36.4%**	**225.45**	**48.5%**			**61,935**

* This percentage indicates the proportion of Community aid dedicated to aquaculture and received by the government, 1994-1999.

** Increase in production between 1994 and 1999 in tonnes. *** Average annual production, 1994-1999.

- The main producing countries accessed Community assistance through FGFI and used it in almost direct proportion to their total output.

- Total public aid varied from 30.1% in Denmark to 91% in Portugal, but for the five leading producing countries, the public participation rate ranges from 45.8% in Greece to 57.9 % in Spain, consistent with the program criteria.

- Spain posted the largest increase in production over the period in question, and the level of public investment public per tonne was 126 euros, the lowest for all member countries.

Figure 2.7 Distribution of Community aid from FGFI dedicated to aquaculture projects, in each member country, 1994 - 1999

Fish Health

In order to broaden trade between member states, including that in live fish, an EU Fish Health Regime was established to limit the spread, across Europe, of the most serious diseases. The regime was based on Council Directive 91/67 (EEC) and subsequent directives and decisions. It established rules on compulsory eradication for the most serious exotic fish diseases (List I) such as Infectious Salmon Anaemia (ISA), and takes into account that, for other serious diseases, the fish health status of aquaculture animals was not uniform across the EU. It introduced the concept of Approved Zones and Farms in relation to other serious diseases (List II), ones for which treatment and vaccination was not available. Introductions to such Approved Zones and Farms were limited to fish stocks from sources of equivalent or higher health status. The regime also provides for the establishment of national controls for certain other diseases (List III), which are a serious problem in some member states and for which treatment and vaccination are not available or possible. Once this has been done, national programs can then be established, with EU agreement, to contain or prevent the introduction of such diseases.

Notifiable diseases

List I Diseases	Diseases exotic to the EU at the time of listing, that pose a serious economic threat to aquaculture and for which treatment or vaccination is not available. The EU regime requires member states to take immediate action to eradicate such diseases should outbreaks occur. List I diseases include Infectious Salmon Anaemia (ISA).
List II Diseases	Diseases which are established in parts of the EU and pose a serious economic threat to aquaculture and for which treatment or vaccination is not available. The EU is zoned by water catchment areas into Approved Zones and Farms (free of the disease(s)) and into areas that are not approved. Movements into Approved Zones or Farms can only take place from areas of equivalent or higher health status. The regime also provides for member states to take action to eradicate these diseases in order to establish Approved Zones and Farms. List II diseases for fish include Viral Haemorrhagic Septicaemia (VHS) and Infectious Haematopoietic Necrosis (IHN) and shellfish diseases such as Bonamiosis, Marteiliosis, Iridovirosis, Mikrocytosis, Haplosploridiosis and Perkinosis.
List III Diseases	Diseases that present a serious problem in some member states and for which treatment or vaccination is not available or possible. With EU agreement, national programs may be established to contain or prevent the introduction of these diseases. List III diseases are therefore country-specific.

It should be mentioned that since 1999, the EU Fish Health Regime does provide a compensation mechanism in relation to eradication orders.

SECTION III

THE INTERNATIONAL CONTEXT FOR AQUACULTURE DEVELOPMENT

ANALYSIS AND DISCUSSION

3.1 LONG-TERM GLOBAL SEAFOOD SUPPLY AND DEMAND OUTLOOK

Over the past 30 years, world aquaculture production has risen from 3.5 million tonnes in 1970 to more than 45 million tonnes in 2000, an average annual growth rate of about 8.9%. For the period 1995-2000 only, aquaculture production volume, including that for aquatic plants, rose from more than 31 million tonnes to more than 45 million tonnes. This represents an increase of 14.5 million tonnes and an average annual growth rate of 7.9%. When production of aquatic plants is excluded, this rate rises to 8.5% (Figure 3.1).

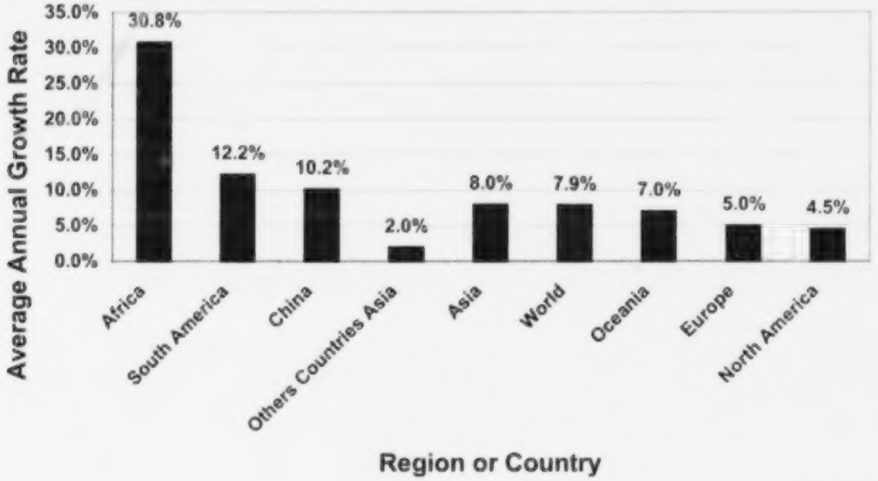

Figure 3.1 ***Average annual growth rate in aquaculture production by continent and for China, 1995-2000***

The continent with the highest growth rate was Africa, at 30.8%. This performance is easily explained by the astounding growth of aquaculture in Egypt. For its part, South America, led by Chile, posted an average growth of 12.2% a year.

China continued to dominate world production with annual growth of 10%. It is interesting to note that the rest of Asia posted growth of just 2% for this period, which is lower than for any of the other continents. Oceania managed to maintain annual growth of 7%, primarily due to Australia and New Zealand. European production rose an average of 5% a year, while North America ranked dead last among the continents with a rate of 4.5%.

Forecasts for global consumption of fisheries and aquaculture products are very complex to develop since consumer behaviour varies widely between regions, countries or continents for a very broad range of products. Forecasts must also factor in estimates of growth in world population and income per capita, which also vary widely. However, the FAO (Ye, 1999) has developed the best model that is currently available. It is based on historic consumption data and each country's Gross Domestic Product, with the results then being pooled by continent.

Based on this analysis, FAO estimates that global human consumption of fisheries products will reach about 183 million tonnes in 2030, a growth rate of about 2% a year starting in the year 2000.

Working from this human consumption forecast, aquaculture production in 2030 was extrapolated, based on the following assumptions:

- commercial fisheries landings, in the opinion of all experts, will stabilize at around 100 million tonnes a year;
- production of fish meal and fish oil will also stabilize, which presumes that growing demand for these products to produce feed for stock will largely be met by inputs from other sources, such as vegetable protein meal; and
- demand for and production of aquatic plants is not considered.

Figure 3.2 shows aquaculture production (excluding aquatic plants), commercial fisheries landings, human consumption, production of fish meal and fish oil, and apparent total demand for fisheries products, based on historic data for 1995-2000 and on FAO forecasts for 2030.

Based on the FAO model and with the assumptions described above, it appears that world aquaculture production could amount to 118 million tonnes in 2030 to meet foreseen demand, which is a tripling of production over the year 2000, or an average annual growth rate of about 4%. Although this sustained growth over such along period may appear rather optimistic, it is important to note that this rate represents less than half the annual growth rate from 1995 to 2000, which was 8.5% (excluding production of aquatic plants).

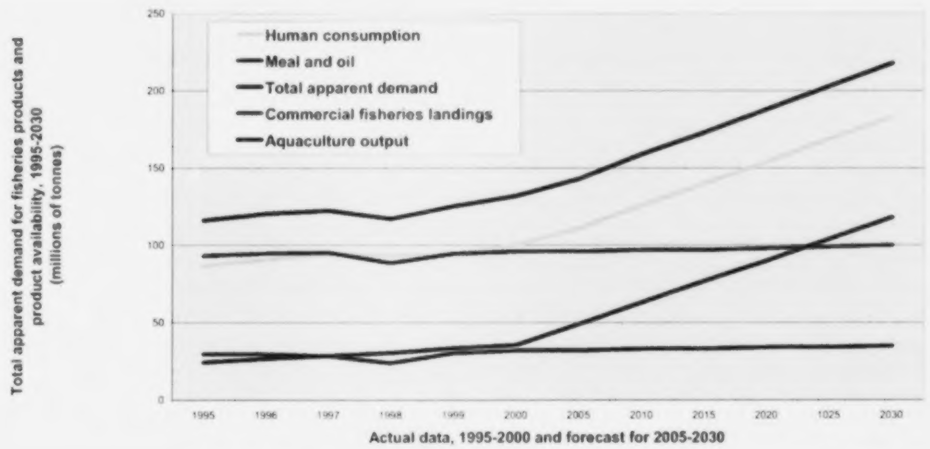

Figure 3.2 ***Aquaculture production (excluding aquatic plants), commercial fisheries landings and total demand for fisheries products: actual data for 1995-2000 and FAO and author forecasts for 2000-2030***

The FAO also forecasts an annual growth rate of 1.8% for agriculture world-wide for the period 2000 to 2010, a rate that is slightly greater than the 1.6% rate experienced from 1986 to 1995. If we take into consideration the forecast growth in global population, growing concerns about consumer health and well-being around the world, and the fact that commercial fisheries landings around the globe have plateaued, it may be concluded that aquaculture should play a growing role in food security in the coming decades.

Thus, aquaculture will be the main source of supply of fish in 2030, and less than half of all marine food will come from capture fisheries. However, given supply constraints, FAO foresees lower demand.

Given the geographic distribution of current aquaculture production and each country's forecast wealth and production, FAO (2000) notes that:

- in wealthy countries, a growing proportion of fish that is consumed will be imported, and since these countries will want to buy fish at the lowest possible cost, most obstacles to trade will likely be eliminated in developed economies;
- aquaculture will undergo geographic expansion, in terms of species grown and technology used;
- it is highly unlikely that Asia will continue to dominate production as heavily as it did in the 1990s;
- mariculture will represent a greater share of total production, especially if offshore aquaculture technology becomes viable;
- through economic growth over the next 30 years, a growing number of people will eat fish regularly and repeatedly;
- a vast range of products will be consumed, but the total quantity of products consumed per person and per year will not vary significantly. In the late 1990s, about 10 percent of the world's population already appeared to have reached this stage, since its fish consumption, in terms of volume, had plateaued. In 2030, the number of consumers in this category will rise slightly, primarily in Europe, but also in a few East Asian countries. However, since population growth will be slower in the wealthy countries than in poor regions, the proportion of the world's population for which consumption has plateaued (in volume) will not increase significantly and should not exceed 20 percent in 2030.

3.2 SUMMARY OF CASE STUDIES

3.2.1 Comparative analysis of national aquaculture sector growth

Among all the countries studied in Section II, Chile posted the highest average annual growth rate between 1995 and 2000, at 15.6%, with production almost doubling in six years. France had the lowest growth, with an average decline in production of 1% a year (Figure 3.3).

This dismal performance by France is explained by a drop of almost 11,000 tonnes in the production of Pacific oysters (the leading species in France), more than 7,000 tonnes of rainbow trout (third most important species) and some 5,000 tonnes of Mediterranean mussels (fourth most important species).

Australia, Norway and the United Kingdom achieved annual growth of 12.3%, 11.9% and 10.2% respectively. This resulted, in every case, in a significant increase in production, from 1.8 times in Australia and Norway to 1.5 times in the United Kingdom. Spain posted growth of 6.9% resulting almost exclusively from an increase of more than 65,000 tonnes in production of blue mussels in six years.

The European Union's production rose from 1 million to 1.3 million tonnes, an annual increase of 3.5%. The United States posted low annual growth of 0.7% because the sharp rise in production of channel catfish (more than 66,000 tonnes) was almost totally offset by significant drops in production of American oysters (63,000 tonnes) and red swamp crayfish (more than 19,000 tonnes).

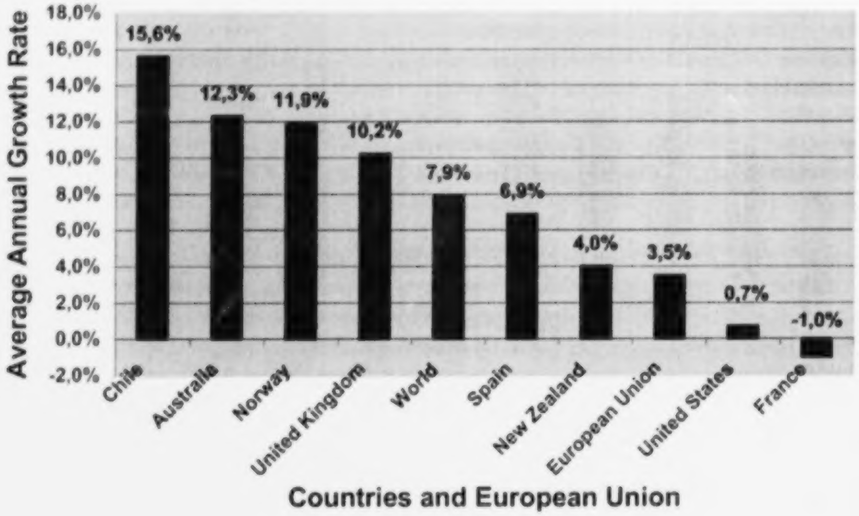

Figure 3.3 Average annual growth rate in aquaculture production for various countries and the European Union, 1995-2000

3.2.2 Approach taken by national governments

Table 3.1 shows the highlights of our analysis of the case studies. For comparison purposes, we also show the current situation in Canada with respect to different criteria: support for sustainable development; regulatory and legal framework; integrated resource management; integration of the aquaculture, fisheries and/or agriculture sectors; industry organization; support for business development; support for research and development; animal health; marketing; food safety; and the level of integration of native communities in development of the sector.

A) *Production development policy*

- All the countries studied support sustainable development of aquaculture. This support varies, however, from country to country and is justified in the eyes of national governments through a combination of benefits, which also vary from country to country. This list of socio-economic benefits includes the fact that aquaculture is a reliable source of quality foodstuffs, that the sector creates jobs and wealth, is a source of foreign currency, makes a major contribution to regional development, participates in land use, etc.

- The obstacles to development of the sector can be grouped under two major constraints: the environmental impact of farming in a receptive natural environment (actual or incorrectly attributed impacts) and the inadequacy of policies and of the legal and regulatory frameworks now in place given the needs of the sector. Major progress has been achieved in the environmental performance of businesses and the sector's image in national public opinion. In fact, in Norway it is thought that all environmental issues have been addressed and nutrient effluent from industry is no longer considered to be an environmental problem. Current issues in Norway now centre more on farmed animal health and controlling escapes by fish.

- In most of the countries studied, the national government, in conjunction with the industry, has established or is about to introduce a clear policy to promote sustainable development of aquaculture. Such policies are often accompanied by production targets for the medium and long term. In these countries, production value is expected to increase by a factor ranging from 1.4 over the next five years, to 8.4 over the next 20 years. Moreover, most countries have developed or are completing an action plan including specific methods to implement the policy and achieve the targets set.

- In most cases, national production is not very diversified. The list of species produced in significant volumes is quite short. This is even more striking in terms of tonnage: the vast majority of national production often consists of just one or two species.

- Government support for development of national aquaculture production focuses primarily on consolidating and expanding existing production (enhanced competitiveness through better farm management practices and technological innovation). However, these are resources devoted to diversification and the emergence of new products.

B) *Legal and regulatory framework*

- Countries that have posted strong growth in production, such as Chile, Norway and Spain, have specific aquaculture legislation. New Zealand will adopt such legislation in 2003. Others, such as Australia and Scotland are planning to do so in the short term. One objective of such legislation is legal recognition of this new major economic sector and thus, clarification of current issues such as ownership of farmed animals and exclusive access to and use of a public resource.

- Two countries have officially decreed a moratorium on issuing new saltwater aquaculture licences: France and New Zealand. These do not reflect a government decision to halt development of their aquaculture sector, but a need to update their legal and regulatory framework to manage development more effectively. In all the other countries studied, public officials admit and the industry is of the opinion that processes for issuing authorizations (permits, licences, leases, authorization certificates, etc.) are unpredictable, cumbersome, often very long and always costly, and thus must be improved. In many countries, the cost, time and energy involved in these regulatory and administrative procedures to access marine sites are seen to hinder small investors and favour large companies, often multinationals. In economic terms, these processes are therefore barriers to entry.

- All countries still have room for expansion in the operation of existing sites. In some cases, new sites are readily available near the coast. Finally, several countries are considering the development of off-shore technology. Sea ranching is also seen as an activity with good growth potential and an excellent way to promote involvement by the fisheries sector in aquaculture.

- All national governments are now modernizing their intervention tools fairly quickly, but the level of advancement varies from one country to another. Australia, Chile, Spain, France, Norway, New Zealand and Scotland will have a new aquaculture policy in effect in 2003 and/or new specific legislation for this sector.

- The organization responsible for supervising aquaculture at the national level is often the ministry or department responsible for fisheries (in three cases out of nine), fisheries and agriculture (3/9), agriculture (1/9: United States), the environment and rural affairs (1/9: Scotland) or the economy (1/9: Chile).

- France restricts access to public marine areas, especially for marine shellfish cultivation, to French citizens only (excluding corporate citizens), but is planning to change this situation by opening access to companies and residents of the European Union.

- Norway restricts concentration of access to sites to 10% of licences issued. Under some conditions, a given company could hold a maximum of 20% of licences. For example, currently, the highest concentration of sites in the hands of a single company currently is 12%, in the salmon industry. In 2001, the Norwegian government decided to prohibit any new concentration of access by a given company in order to provide time to set new rules for the whole issue of ownership of Norway's aquaculture industry.

C) Integrated resource management

- To solve the problem of conflicts between users of the aquatic environment through transferring more decision-making power to local authorities, three countries apply integrated resource management concepts (Australia, Chile and Norway) and two others plan to start using these concepts in 2003 (New Zealand and Scotland). For its part, the European Union has issued a new directive to this effect in 2002, urging member countries to introduce such practices.

D) Aquaculture / Fisheries / Agriculture Integration

- Integration of aquaculture activities into related sectors such as agriculture and fisheries is seen by several countries as a tool to foster aquaculture development and a way to create synergy for optimizing benefits for the producer and the national economy. Australia favours integration of freshwater aquaculture (land-based) into agricultural activities. Chile has adopted new regulations favouring the granting of marine concessions to communities of fishers for development of sea ranching activities. Norway increasingly refers to a halieutic sector encompassing traditional fisheries activities as well as aquaculture. In its new aquaculture development strategy, the European Union openly advocates shifting the fisheries workforce to aquaculture in areas affected by sharply declining catches.

- This integration is achieved, especially in organizations representing the industry, through amalgamation of sectoral associations into a single entity, as in Norway, or at least through assembly into national sea-based or marine product industry councils, as in Australia or New Zealand.

E) Industry organization

- In all the countries studied, we found a strengthening of industry representation within increasingly well structured associations, driven in particular by the need to better serve their members' interests with governments, that are intervening more and more in the sector.

- The best funded industry organizations are those making direct deductions at source, either as a percentage of annual volume produced or of product value, for each member.

- In most countries, national industry organizations have adopted a code of good conduct or codes of good practice.

F) *Business financing*

- Most countries provide direct financial support for business development, to expand production capacity and/or enhance the competitiveness of existing production units. Chile, the United States and New Zealand are the only exceptions. The European Union, with its *Fisheries Guidance Financial Instrument*, is showing strong leadership with respect to member countries and its intervention, carried out collaboratively with these countries, covers all segments of the industry, from production to organization of marketing, as well as processing and support for quality.

- The aquaculture industry enjoys tax incentives that provide some tax discounts on products and services or income tax deductions. These programs are generic and not specific to aquaculture. They often cover all industrial or primary production sectors (mining, forestry, agriculture, fisheries, etc.).

G) *Risk management programs*

- Only the United States and Spain currently have harvest insurance programs established specifically for aquaculture, covering respectively the farming of quahogs in USA and gillthead bream, sea bass, turbot, mussel and trout farms in Spain. In USA, the quahog program is a pilot project that will be subject to a full review in 2004. Other American products, such as Atlantic salmon, may be covered by such programs in the foreseeable future. In Spain, the programs are also at the experimental stage.

- In Australia, freshwater aquaculture producers can access farm income stabilization programs.

- Australia, Chile, the United States and Scotland have ad hoc programs to offset major stock losses as a result of serious but non-recurring natural disasters.

H) *Research, uevelopment and technology transfer*

- Without exception, all governments of the countries studied allocate significant resources to research and development. All these countries have what may be described as a national R&D institute for aquaculture (often jointly with the fisheries sector) that supports intramural and/or extramural programs of research. Several provide funding for research in other public or private institutions, and directly to businesses conducting R&D projects.

- Norway is the only country that has established a fisheries and aquaculture research fund under the responsibility of the Ministry of Fisheries, with 100% of funding provided by fisheries and aquaculture operators through mandatory deductions from their export income. The industry plays a decisive role in grants from this fund to R&D projects. Since this fund is barely a year old, it is still too early to evaluate its performance.

- All governments also allocate resources to technology transfer activities where this is a key component of the innovation process that fosters adaptation and use by the industry of new technology and other findings from R&D.

- It should be noted that a few countries, such as Australia, the United States and France are actively promoting the development of offshore farming technology. This government initiative is justified by various arguments ranging from a lack of adequate inshore sites for desired expansion of the sector, to resolution of conflicts between users of the aquatic environment by moving aquaculture facilities away from the shore.

- Only the United States federal government funds multidisciplinary, integrated services to support aquaculturists (extension services).

I) Aquatic animal health

- Most countries have introduced a national aquatic animal health program that takes an integrated approach to this important aspect of aquaculture and delivers traditional services to the industry for health monitoring, as well as monitoring and rapid response measures for any emergency resulting from an epidemic. These programs receive significant financial support from the central government, although it often continues to be deemed inadequate in many cases.

- To the best of our knowledge, only France has a standards-based program to provide automatic compensation for part of losses incurred by a producer following an eradication order. However, this program covers only infectious salmon anemia. This type of program is now approved by the European Union under the FGFI fund.

- In most cases, the industry must cover part of the cost of services related to farmed aquatic animal health (for fish as well as shellfish).

J) Food safety

- The safety of aquaculture products is considered a major and vital component of government intervention in all the countries studied.

- We find that standards are now being strengthened in most countries, which provides one more sales argument for exports from a given country and a further barrier to entry of seafood imports into the same country.

K) *Marketing and trade*

- All national governments directly support development of foreign markets and exports of aquaculture products. This is done through programs introduced specifically for aquaculture (Australia, European Union member countries) or through more generic programs (Norway).

- Two countries have a national organization dedicated to promoting exports of their aquaculture products: Norway and Scotland. Norway's council for marine product exports was established by law and is funded through mandatory deductions on all products exported from Norway. Scottish Quality Salmon (SQM) is a wholly private corporation also funded through deductions from exports of Scottish products, but these are voluntary since they apply solely to exports by businesses that have decided to become members and thus take advantage of the services provided by SQM.

L) *Native peoples and aquaculture*

- Australia, Chile, the United States, Norway and New Zealand have native communities. Only Australia is planning in the short term to develop a national strategy for involving native peoples in aquaculture.

- The process of legal and regulatory reform of aquaculture in New Zealand faces serious difficulties due to native community claims that were not taken into account for the initiative in a timely fashion.

Table 3.1 **Principal results of case studies and comparison with Canada.**

Criteria	Australia	Chile	Spain	USA	France	Norway	New Zealand	UK/ Scotland	European Union	Canada
Official governmental support for sustainable industry growth	YES	YES	YES	YES	Weak	YES	YES	YES	YES	YES
Aquaculture Policy	Upcoming	2003	NO	YES	Upcoming (marine)	YES	2003	2003	YES	YES
Strategic / Action Plan	YES	YES	NO	YES (R&D)	NO	NO	2003	2003	YES	NO
Annual growth rate*	12.3 %	15.6%	7.0%	10.7%	-1.0%	11.9%	4%	10.2%	3.5%	13.9 %
Production value in 2000	$ 644 million	$ 1.9 billion	$ 568 million	$ 1.3 billion	$ 644 million	$ 2.1 billion	$ 80.3 million	$ 670 million	$ 3.9 billion	$691million
Production value target	$ 2.16 billion	$ 6.6 billion	NO	$ 7.4 billion	NO	NO	$ 678 million**	NO	4%/year	$3.1 billion
In	2010	2020	--	2025	--	--	2020	--	2008	2010
Target / 2000 value	3.4	3.5	--	5.7	--	--	8.4	--	1.4	4.5
Job creation	29, 000	--	--	420, 000	--	--	--	--	9 000	--
Aquaculture Act	NO	YES	To be updated	YES	YES (marine)	To be updated	2003	NO	N/a	NO
Aquaculture / products legal existence	NO	YES	YES			YES				NO
Lead Agency (sector)	Agriculture and Fisheries	Economy	Agriculture and Fisheries	Agriculture	Agriculture and Fisheries	Fisheries	Fisheries	Environment	Fisheries Commission	Fisheries
Site access process	To streamline	To streamline	To streamline	To streamline (marine)	Official Moratorium Marine	To streamline	Official Moratorium	To streamline	N/a	To streamline
Industry Ownership Restrictions	NO	NO	NO	NO	YES (marine)	YES	NO	NO	NO	NO
Integrated Management (ICZM)	Land YES Marine : upcoming	YES	NO	NO	NO	YES	2003	2003	YES	NO
Integration with Fisheries and /or Agriculture	YES	Upcoming	NO	NO	NO	Strong	YES	NO	Fostered	NO
Industry Organization										
Structure	Weak	Strong	Strong	Strong	Strong	Strong	Weak	Strong	Unique	Strong
Levy	NO	YES	YES	NO	NO	YES	YES	NO	NO	NO
COC or COP***	YES (COC)	NO	NO	YES (COP)	NO	NO	YES (COP)	YES	YES (COC)	YES (COC)

* Annual growth rate for 1995-2000. ** Industry's forecast *** Code of Conduct (COC) or Code of Practice (COP)

Table 3.1 Principal results of case studies and comparison with Canada (continued).

Criteria	Australia	Chile	Spain	USA	France	Norway	New Zealand	UK/ Scotland	European Union	Canada
Industry Development Subsidies or grants	FEW	NO	YES (FIFG)	NO	YES (FIFG)	YES	NO	YES (FIFG)	YES (FIFG)	NO
Safety Net Programs										
Aquaculture specific	NO	NO	YES	YES	NO	NO	NO	NO	N/a	NO
General	YES	NO	YES	YES(Fresh)	YES	NO	NO	NO	N/a	NO
Disaster	YES	YES	YES	YES	YES	NO	NO	YES	N/a	YES
Taxes Incentives	FEW	NO	NO	YES	YES	YES	NO	YES	N/a	YES
R&D Public Support										
National Institute	YES	YES	YES	YES	YES	YES	YES	YES	N/a	NO
Aquaculture specific P.	YES	NO	YES	YES	NO	YES	YES	YES	YES	NO
General Program	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Funds /Levy	NO	NO	NO	NO	NO	YES	NO	NO	N/a	NO
Technology Transfer Pr.	YES	YES	YES (FIFG)	YES	YES (FIFG)	YES	YES	YES (FIFG)	YES (FIFG)	NO
Offshore technology Development	YES	NO	NO	YES	YES	NO	Upcoming	NO	YES (foster)	NO
Extension Services	NO	NO	NO	YES	NO	NO	NO	NO	N/a	
National Fish Health Regime/Program	YES	NO	YES (EU)	YES	YES (EU)	YES	NO	YES (EU)	YES	NO
Eradication Order with Compensation		NO		NO	YES	NO	NO	NO	YES	NO
Public Services Cost Recovery	YES	NO	NO	NO	NO	YES (partially)	YES (totally)	NO	NO	
Food Safety Program	Strong	Strong	Strong	Strong	Strong	Strong	Strong	Strong	Strong	Strong
Marketing/Exports Prog.										
Aquaculture specific	YES	NO	YES (FIFG)	NO	YES (FIFG)	NO	NO	YES (FIFG)	YES (FIFG)	NO
General	YES	NO	YES	YES	NO	YES	NO	YES	NO	YES
Private Exp. Council	NO	NO	NO	NO	NO	YES (Levy)	NO	YES (Levy)	N/a	NO
Aboriginal Strategy/Integration	Upcoming	NO	N/a	NO	N/a	NO	NO	N/a	N/a	NO

3.3 SOME FACTORS THAT WILL DETERMINE GLOBAL AQUACULTURE PERFORMANCE

As is the case for all major bio-food operations, aquaculture follows a standard development pattern: the *pioneer phase* is followed by exponential growth of production, which plateaus once supply meets any demand for products. The pioneer phase may be quite long, often extending over several decades. This is the period when the first investors and entrepreneurs become interested in a given product, use the results of basic research, invest time and money in applied research and development of production methods, and through trial and error, eventually master the production cycle, set performance standards and cut production costs below the price paid for finished products on a regular basis.

Once this stage is reached, massive investment usually occurs in development of production units *(exponential growth phase*) because the risk associated with production is now perceived to have dropped to a level where satisfactory financial returns have become possible, making it easier to attract the necessary capital.

The third and final phase, in theory, is stabilization or maturation: supply meets demand and growth in production slows markedly. Lower prices usually translate into lower financial returns.

Under this simple analysis, the world aquaculture sector, taken as a whole, has fully entered the exponential growth phase. Although in many cases, aquaculture production for a given species takes place for hundreds of years or longer, in recent years we have witnessed a sharp rise in production of these traditional species. The emergence of new products is now meeting demand for an ever broader range of fisheries products.

For aquaculture at both the international and regional levels to contribute fully to the supply of fisheries products needed for future food security, it must meet the many challenges it now faces. These factors will determine the ability of aquaculture to capitalize on available opportunities for growth. In some cases, the industry can directly influence these factors, but in others cases the industry has less control.

3.3.1 Sustainable Development

Some aquaculture production has undergone massive growth over the past two or three decades, but little consideration has been given to its real impact on the environment. On the other hand, the aquaculture sector has not paid necessary attention to the effect on public opinion of environmental impacts that are wrongly attributed to the industry. Although, in all fairness, aquaculture can generally be considered to be a more sustainable sector than many other food production operations, several major developments, deemed environmental failures, remind us that it can also have significant negative effects on the environment.

Growth of this sector cannot continue without the aquaculture industry fully integrating the concept and principles of sustainable development, defined as development that meets current needs without compromising the opportunity for future generations to meet their own needs. Public pressure on this issue is growing in many countries for the aquaculture sector as well as for other food and industrial operations. Aquaculture cannot escape this trend.

Sustainable development therefore involves preserving biodiversity (protecting indigenous species, maintaining the gene pool, etc.), limiting inputs of chemicals that may have a permanent impact, and conducting research and development, especially in nutrition, to reduce release of nutrients into the environment. Huge progress has been made in this regard in recent years. One obvious example is the development of high-energy diets that have significantly lowered the food conversion rate, or work on the use of vegetable meal and oils in feed. FAO forecasts for growth of the aquaculture sector and stable landings from commercial fisheries will drive increasingly strong demand for feed inputs that certainly cannot be met solely by fish meal and fish oil. As a result, pressure will mount to develop feeds containing a high proportion of vegetable proteins, thereby lowering pressure in fish stocks.

One industry response to environmental criticism has been to introduce codes of best environmental practices (often based on the FAO's Code of Conduct for Responsible Fisheries) and other production management systems. Initially applied on an individual, voluntary basis, these systems are increasingly proving less effective than hoped, in terms of application as well as the image they generate among pressure groups, with no verification mechanism and follow-up, ideally by a third party (Howell, L.A. ed., 2001). The trend is toward implementation of increasingly strict monitoring systems on the farm, such as ISO 14 001 or HACCP.

3.3.2 Integration of aquaculture into the local and national social fabric

In many countries, growth of aquaculture, often quite rapid, is a recent phenomenon. Although this activity has major economic benefits, especially in terms of jobs created in regions where other opportunities are often fairly limited, this sector has grown in a modern context, where conflicts between various current and potential users of resources are common and where *ordinary* citizens are well aware of their existing rights or privileges and are quick to defend them. The aquaculture industry has not always considered this social context, which has significant impact on its ability to obtain access to the resources, often public, needed for its development.

Projecting a positive image of the sector, initially at the local level, obviously forms part of including this activity in the social fabric, thereby facilitating conflict resolution. A positive national perception of aquaculture is also dependent on solid acceptance of businesses at the local level. This responsibility rests above all on the industry, which must be able to present the development of aquaculture as a whole, in a positive manner. It must demonstrate all the benefits derived from the sector, both economic and social, which far outweigh its drawbacks (temporary environmental impact, for example).

3.3.3 Intersectoral and Intra-Sectoral Competition and Industry Competitiveness

In the market, to continue to be attractive, aquaculture products must be affordable for as many consumers as possible and thus must be sold at prices that are competitive with those for all substitute foods. Aquaculture products therefore must continue to be attractive vis-à-vis intersectoral competition.

To this end, the aquaculture sector's level of competitiveness will be enhanced by the increase in production volume that is predicted, as well as the development and adoption of new technology. R&D activities will have to continue in areas such as nutrition, farming systems (intensification of processes, integration of various products, use of water recirculation and recycling, for example), management of stock health (diagnostic tools, development and availability of therapeutic products, inventory management, etc.) and genetic enhancement of biological performance, through either traditional (genetic selection) or more innovative approaches.

In the latter case, biotechnology in general and genetic modification of organisms in particular provide a series of opportunities that have not been greatly explored to date. The prevailing situation in many countries is not yet very favourable to the use of these methods, with the explanation given for this being that the resulting products might have a negative impact on human health or the environment. Under the current stage of development of this technology, these fears are much more the result of moral, philosophical or even ethnic considerations than positions based on solid scientific evidence and, therefore, no longer open to criticism. However, incorporating the benefits of biotechnology into aquaculture production systems obviously will not be possible without consideration of the prevailing social context at the time, and anticipated consumer reaction.

For some products such as shellfish, experts believe that extensive feeding of organisms in the natural environment (sea ranching) using selected spats produced in hatcheries provides good potential for the development of mariculture. This production method provides the merit of being less costly, in theory, than semi-intensive operations (suspended stock on floating structures, for example), and requires less human intervention throughout the production cycle. This technique also offers the option of promoting better integration of the traditional fisheries and aquaculture sectors. Given the fact that in many regions of the world, inshore and deep-sea fisheries are in decline, government organizations such as the Commission of the European Communities are planning to redeploy work forces from fisheries into such activities as aquaculture.

For other regions, such as Africa and Asia, the synergy resulting from integration of aquaculture activities into existing agricultural activities is viewed as an effective way of boosting the productivity of both types of activity.

In general, however, it is easy to foresee that, globally, aquaculture production systems will tend to intensify, in terms of production technology, over the long term.

In the area of intra-sectoral competition, between different or similar aquaculture products coming from large-scale industrial production (common in the developed countries) and non-industrial production (common in the developing countries), some increase in competition may ultimately be expected, especially in lucrative species. For example, we are not likely to see a growing supply of European and North American markets with species such as tilapia from foreign non-industrial operations. It is more probable that the market will foster domestic aquaculture operations based on intensified production and enhanced biological performance that will offset low production costs achieved in other locations through more extensive methods.

3.3.4 Safety of aquaculture products

Reliable safety of aquaculture food products is definitely a key characteristic of marketing these products in domestic markets. The rules governing these criteria have been reviewed or are under review in many countries to respond more effectively to the current situation, resulting from a growing consumer concern in this regard. We find, however, that food safety will continue to play an increasingly dominant role, if not a deciding one, in export markets because a growing number of countries require quality certification before admitting these products into their own market.

Over time, therefore, this non-tariff barrier will dictate the introduction of HACCP-type or other control systems for all industries serving export markets. In conjunction with this, there is growing reference to producing tracking systems to retrace defective products to their source. These new rules will indirectly impact grower practices, especially those affecting animal health.

3.3.5 Market access and public opinion

Aquaculture products are shipped to very competitive markets where products from other industries such as fisheries and agriculture are also for sale. Consumers.are therefore being pursued actively.

The performance of these other industries in terms of competitiveness and image will affect the performance of aquaculture. For instance: a major breakthrough by a substitute product or group of products; a radical change in consumer habits (such as enthusiasm for products with characteristics rightly or wrongly perceived as being beneficial to health); population growth world-wide that is significantly below or above forecasts; these are all potential changing conditions that could have decisive effects on the growth of aquaculture. All these factors will determine the so-called *natural* limits of markets open to aquaculture products.

To achieve its full potential, aquaculture also must not create *artificial* limits resulting from a poor image of production methods (unacceptable environmental performance in the opinion of the general public) or products (poor quality or negative impact on health). A decline in supplies to markets will simply benefit competing or substitute products. This type of trend in consumer behaviour is often very difficult to reverse once these *artificial* limits are firmly rooted in the minds of consumers and the general public.

3.3.6 Government intervention

A sector's competitiveness is also dependent on the legal and regulatory environment established by governments, since such constraints can have a considerable impact on production costs. Furthermore, this environment is definitely a major factor in the decision-making process used by multinational companies to select a geographic location.

In the context of liberalization of imports and exports, a national government's attitude and assistance are therefore key factors in the performance of its industry compared with that of competitors in global markets.

An overview of production statistics quickly shows that countries where national production has risen significantly in recent years have a policy that clearly favours aquaculture, with adequate implementation, and a modern government structure that meets the industry's needs while ensuring its citizens that this occurs with sustainable development principles being respected. In some cases, the truly private nature of the industry's economic activities is legally recognized under quasi- private ownership rights of what originally is a public resource.

At various levels and with major variations throughout the world, government support may address all or part of the industry's needs, from innovation (R&D) to academic and customized training, from technical support to operations (technology transfer, veterinary services, health certification, etc.) to direct and indirect enterprise development assistance, and from zoning policies or integrated management that facilitate access to production sites, to direct or indirect marketing support.

Achieving aquaculture's full potential therefore will also depend on the importance national governments and community and international organizations place on this industry. In many cases, a positive government attitude has generated convincing results, as the performance of Norway, Chile or Egypt attest.

CONCLUSION

Analysis of supply and demand for fisheries products reveals solid potential for growth of aquaculture in the coming years. However, as suggested by De Silva (2001) and other authors who have studied this issue, a comprehensive strategy for achieving this potential must include two components: 1. a significant increase in production to maintain a growing impact on global food security, the creation of economic benefits, rising household wealth and thus enhanced social equity; 2. development that reflects the environment's capacity to support operations and therefore includes the dictates of sustainable development.

Many national governments have strived to provide a more effective framework for the sector's development. This initiative is not driven by a desire to restrict or control expansion of an industry that has, at times, performed poorly in environmental or social terms, but rather by the enormous potential of aquaculture and the need to modernize the legal and regulatory structure to support sustainable development of this sector.

Other countries, including those that have achieved the best growth performance for their industry in recent years, have already established a policy that clearly favours aquaculture, following a full analysis of the net economic and social benefits offered by this sector.

Every industrial activity has an impact on the environment. Ultimately, a society must choose the type of food production that provides the best yield in terms of the private or public resources employed, produces foods and other products that best meets the current and future needs of consumers, generates the best economic and social benefits, and has the least impact on the environment, with the effects being reversible. Many governments around the world have specifically declared, or are preparing to do so, that this type of production includes aquaculture.

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